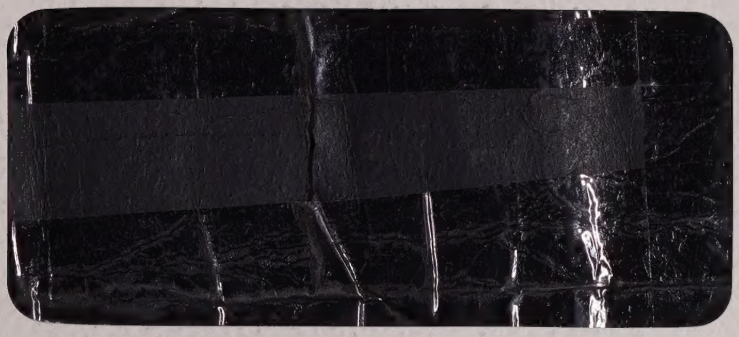


SINGER
INSTRUMENTATION

INSTRUCTION MANUAL

Panoramic*

SPECTRUM ANALYZER

MODEL SPA-10

*A Trademark of THE SINGER COMPANY

Precision electrical and electronic instruments for measurement

THE SINGER COMPANY • METRICS DIVISION

IB5005

WARRANTY

THE SINGER COMPANY, METRICS DIVISION, warrants each new instrument to be free from defects in material and workmanship, effective after delivery to the original purchaser as follows:

*Commander** Instruments: Potentiometers, Bridges,
Volt Ratio Boxes and Standard Resistors.....5 years
*Sensitive Research** Electrical Indicating Instruments.....2 years
Other Electrical and Electronic Measuring Instruments.....1 year

Repair or replacement (at our option) without charge (F.O.B. factory) will be effected when our examination satisfactorily indicates that defects are due to workmanship or materials. Electron tubes, semiconductors, batteries, fuzes, lamps, thermoelements, and *RatioTran** potentiometers are excluded from warranty coverage. Warranty returns must first be authorized by the factory.

If the instrument or any portion thereof, has been abused, misused, damaged by accident or negligence, or if any serial number or seal has been removed or altered, the warranty is void.

This warranty is in lieu of all other obligations or liabilities expressed or implied and The Singer Company neither assumes, nor authorizes any person to assume for them, any other liability in connection with sales of instruments manufactured by The Singer Company, Metrics Division.

THE SINGER COMPANY • METRICS DIVISION
915 PEMBROKE STREET, BRIDGEPORT, CONNECTICUT • 3211 S. LA CIENEGA BLVD., LOS ANGELES, CALIFORNIA

*A Trademark of THE SINGER COMPANY

REPAIR AND MAINTENANCE

Instruments should be returned only on prior written authorization from the Singer Representative or the factory(1). Warranty repair will be made upon written request. Please provide the following information in order to expedite our processing of your instrument:

1. Model or Type
2. Serial Number
3. Description of trouble(2)
4. Test instruments used
5. Approximate date instrument was placed in operation
6. Approximate number of hours of use
7. Has maintenance action been previously requested?
8. Other comments

Upon receipt of this information our Service Department will send you service data or shipping instructions. Upon receipt of shipping instructions forward the instrument to the factory prepaid. If requested, an estimate of charges will be made before work begins.

(1) Contact Metrics Division, Bridgeport, Connecticut for *Commander**, *Empire**, *Panoramic**, and *Sensitive Research** instruments. Contact Metrics Division, Los Angeles, California for *Gertsch** instruments.

(2) Include data on symptoms, measurements taken, suspected location of trouble, maintenance action taken, and any other relevant data.

TABLE OF CONTENTS

Para.		Page
	SECTION 1 — GENERAL INFORMATION	
1-1.	General	1-1
1-5.	Application	1-1
1-7.	Equipment Supplied	1-1
1-9.	Accessory Equipment	1-1
1-11.	General Description	1-1
1-28.	Electrical Characteristics	1-3
1-49.	Mechanical Characteristics	1-9
1-52.	Optional Equipment	1-9
	SECTION 2 — INSTALLATION	
2-1.	Unpacking and Initial Inspection	2-1
2-4.	Installation Procedures	2-1
	SECTION 3 — OPERATION	
3-1.	General	3-1
3-4.	Operating and Adjustment Controls	3-1
3-40.	Preliminary Operating Procedures	3-10
3-43.	General Operating Procedures	3-10
3-87.	Specialized Operating Procedures	3-19
3-105.	Optional Equipment Operation	3-26
	SECTION 4 — THEORY OF OPERATION	
4-1.	General	4-1
4-3.	Tuning Head	4-1
4-12.	Indicator Unit	4-3
	SECTION 5 — MAINTENANCE	
5-1.	General	5-1
5-6.	Test Equipment and Special Tools	5-1
5-8.	Minimum Performance Standards Checks	5-3
5-29.	Trouble Shooting	5-9
5-32.	Gain Measurements	5-17
5-38.	Waveshape Examination	5-19
5-40.	Voltage and Resistance Measurements	5-19
5-42.	Removal and Replacement	5-20
5-55.	Adjustment and Alignment	5-38
5-93.	Alignment	5-52
5-114.	Crystal Calibrator Maintenance	5-65
5-116.	Calibrator Alignment	5-65
	SECTION 6 — REPLACEMENT PARTS LIST	
6-1.	General	6-1
	SECTION 7 — SCHEMATICS	

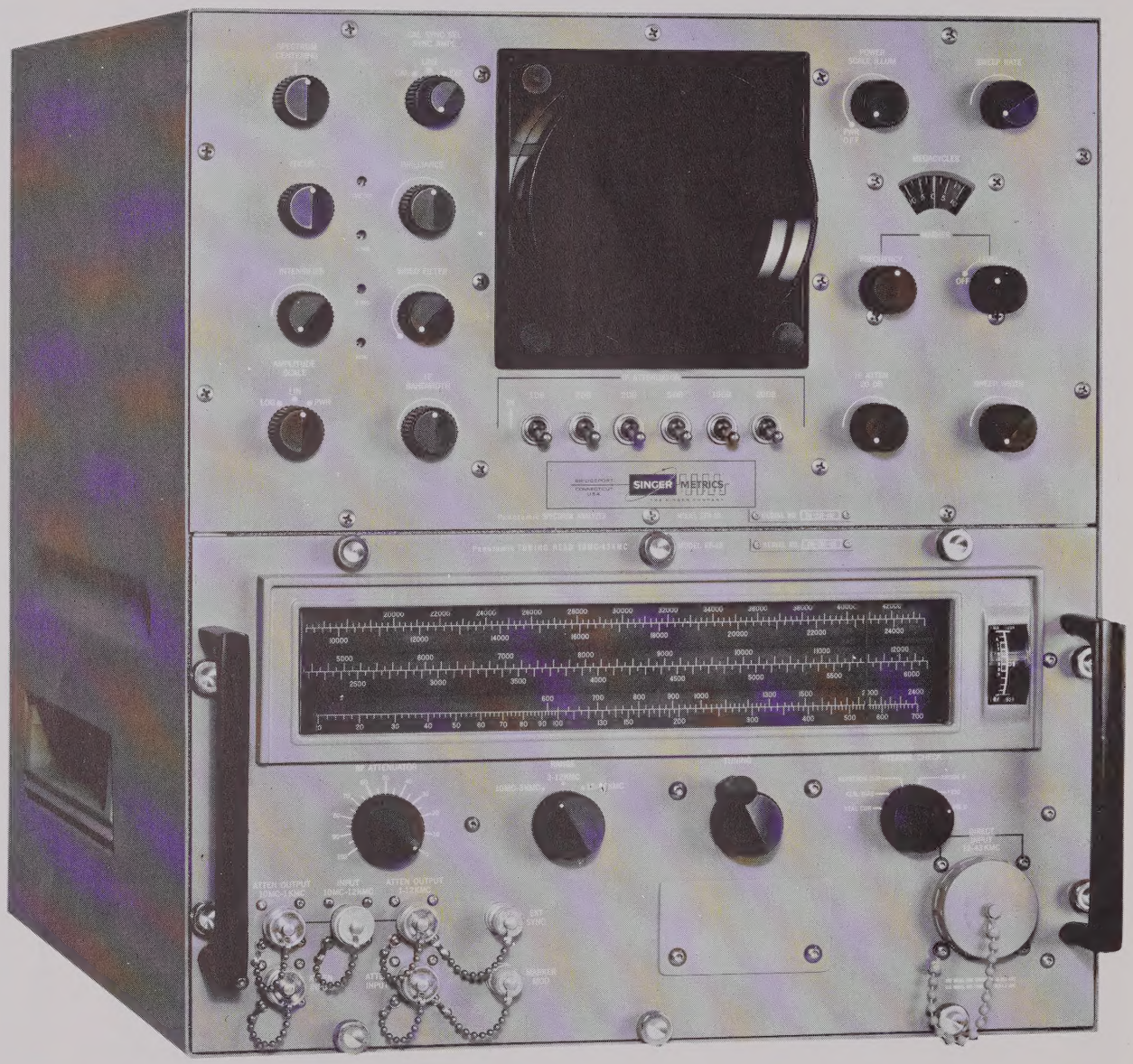
LIST OF ILLUSTRATIONS

Figure		Page
1-1.	PANORAMIC Spectrum Analyzer, Model SPA-10	iv
1-2.	Bandwith vs Sweep Width	1-6
2-1.	Outline Dimensions, Rack-Mounted Version	2-2
2-2.	Power Conversion from 115 to 230 VAC, Schematic Diagram	2-3
3-1.	Front Panel-Operating and Adjustment Controls	3-2
3-2.	Correct Viewing Position	3-5
3-3.	Improved Sensitivity Resulting from Reduced Sweep Width	3-6
3-4.	Effects of Progressive IF Bandwidth Reduction	3-7
3-5.	Progressive Separation of Closely Spaced Signals	3-8
3-6.	Progressive Resolution of Two Signals of Unequal Amplitude	3-8
3-7.	Effects of VIDEO FILTER Control Rotation	3-9
3-8.	Effects of INTENSIFIER Control Rotation	3-9
3-9.	Incidental FM	3-11
3-10.	Spectrum of .01 Microsecond Pulse	3-12
3-11.	Wavemeter Measurement Test Set-up	3-13
3-12.	Typical IF Flatness Curve	3-16
3-13.	Amplitude Modulated Signal Showing Sidebands	3-18
3-14.	Frequency Modulated Signal	3-18
3-15.	Pulsed Signal at Fast and Slow Sweep Rates	3-19
3-16.	Insertion Loss Test Set-up	3-20
3-17.	VSWR Test Set-up	3-21
3-18.	Typical VSWR Response Curve	3-21
3-19.	Wavemeter Calibration Test Set-up	3-21
3-20.	Visual Frequency Comparison Test Set-up	3-21
3-21.	Filter Response Test Set-up	3-22
3-22.	Typical Filter Response Curve	3-22
3-23.	Typical Example of Microphonic Effects	3-23
3-24.	Spectrum of Balanced Modulation	3-24
3-25.	Transmitter Output Test Set-up	3-25
3-26.	Klystron Phase Locking, Equipment Test Set-up	3-26
4-1.	Tuning Head, Block Diagram	4-2
4-2.	Indicator Unit, Block Diagram	4-4
5-1.	Calibration Signal Synchronized at 30 cps	5-4
5-2.	Expanded Pip Display	5-6
5-3.	Optimum Resolution	5-6
5-4.	Signal Pip Centered on Screen	5-8
5-5.	FM Breakup	5-9
5-6.	Screen Display at 2:1 Signal-to-Noise Ratio	5-9
5-7.	Waveforms - IF-Video Amplifier	5-20
5-8.	Waveforms - Horizontal Sweep Generator and Amplifier	5-21
5-9.	Waveforms - AGC Amplifiers and Sawtooth Driver	5-22
5-10.	Dummy Load	5-28
5-11.	Indicator Unit - Right Hand View	5-31
5-12.	Indicator Unit - Left Hand View	5-32
5-13.	IF-Video Chassis	5-33
5-14.	Indicator Unit - Rear View	5-34
5-15.	Indicator Unit - Top View	5-36
5-16.	Indicator Unit - Bottom View	5-37
5-17.	CRT Power Supply - Cover Removed	5-38
5-18.	Tuning Head - Right Hand View	5-39
5-19.	Tuning Head - Rear View	5-40
5-20.	Tuning Head - Top View	5-41
5-21.	Triode Oscillator - Top View (Cover Removed)	5-42
5-22.	Triode Oscillator - Bottom View (Cover Removed)	5-43
5-23.	Tuning Head - Bottom View	5-45
5-24.	Klystron Cavity - Assembled (Typical)	5-46
5-25.	Klystron Cavity - Disassembled (Typical)	5-47

Figure		Page
5-26.	Dial Cord Installation	5-51
5-27.	Klystron Mode Modulator	5-56
5-28.	Klystron Modes	5-57
5-29.	Repeller Mode Characteristics - 6BL6 Klystron	5-58
5-30.	Amplifier-Filter Test Set-up	5-61
5-31.	160 MC Narrow Band Filter Response Curve	5-61
5-32.	75 MC Filter Response Curve	5-61
5-33.	160 MC Amplifier Response Curve	5-62
7-1.	Tuning Head, Schematic Diagram	7-1
7-2.	Tuning Head, Schematic Diagram	7-2
7-3.	Wideband IF Amplifier and Marker, Schematic Diagram	7-3
7-4.	Video IF Chassis, Schematic Diagram	7-4
7-5.	Sweep Generator, Horizontal Amplifier and CRT, Schematic Diagram	7-5
7-6.	Power Supply, Schematic Diagram	7-6
7-7.	Crystal Calibrator, Schematic Diagram	7-7

LIST OF TABLES

Table		Page
1-1.	Accessory Kit Components	1-2
1-2.	Specifications	1-4
1-3.	Frequency Band Specifications	1-5
1-4.	Tube Complement	1-8
3-1.	Operating and Adjustment Controls	3-3
5-1.	Recommended Test Equipment and Special Tools	5-1
5-2.	Troubleshooting	5-10
5-3.	Internal Check Meter Indications	5-16
5-4.	Stage Gain Measurements	5-17
5-5.	Voltage and Resistance Measurements	5-23
5-6.	Interconnecting Cables	5-29
5-7.	Tube Socket Voltage and Resistance Chart - Crystal Calibrator	5-67



5005-1

Figure 1-1. PANORAMIC Spectrum Analyzer, Model SPA-10

SECTION 1

GENERAL INFORMATION

1-1. GENERAL

1-2. This Instruction Manual has been prepared to assist in the installation, operation and maintenance of the PANORAMIC Spectrum Analyzer, Model SPA-10, manufactured by The Singer Company, Metrics Division, Bridgeport, Connecticut. (See figure 1-1.)

1-3. The information contained in this manual refers to the standard version of the analyzer with available options and is current only to the date of publication. Differences in analyzer components, specifications, and performance resulting from subsequent engineering improvements or customer requirements are described in applicable addendum sheets.

1-4. No attempt to operate this equipment should be made until the operator is thoroughly familiar with the information contained in SECTION 3 — OPERATION.

1-5. APPLICATION.

1-6. The following uses represent only a few of the many applications of the analyzer. Inquiries are invited regarding special applications of this equipment to particular requirements.

a. Visual examination of oscillator or transmitter performance.

b. Monitoring communications channels and radar-frequencies.

c. Analyzing pulsed signals.

d. Analysis of spectra associated with AM, FM, and PM signals.

e. Direct reading of power points and nulls.

f. Studies of malfunctions in microwave equipment (e.g., spurious signals, instabilities, microphonic effects, etc.).

g. Noise spectrum studies.

h. Harmonic and other out-of-band measurements.

i. Examination of CW signals for frequency drift, incidental FM, and squegging.

j. Examination of dynamic operating characteristics of microwave tubes.

k. Checking for RF leakage and radiation.

m. Determining presence and frequency of RF signals.

n. As a sensitive receiver to measure characteristics of microwave components or circuits (e.g. insertion loss and VSWR measurements).

1-7. EQUIPMENT SUPPLIED.

1-8. Unless otherwise specified, the equipment supplied consists of the standard Model SPA-10, with cabinet, and the Accessory Kit, Part No. 556019-172. Components of the Accessory Kit are listed in table 1-1.

1-9. ACCESSORY EQUIPMENT.

1-10. While the analyzer is entirely self-contained and will operate without any external devices, some accessory equipment may be required for certain applications. The use of external accessories such as wavemeters or attenuators is described for several typical applications in SECTION 3 — OPERATION. Recommended models of these devices are listed in table 5-1.

1-11. GENERAL DESCRIPTION.

1-12. This spectrum analyzer is a sensitive microwave receiver-indicator which automatically scans a selected frequency spectrum segment and displays an amplitude vs frequency Fourier analysis of input signals within the swept band on a cathode ray tube indicator. It is useful for CW, AM, FM and pulsed signal measurements.

1-13. The analyzer consists basically of two modular sections, the Tuning Head, Model RF-10 (lower section) and the Indicator Unit (upper section), which are integrated into one compact unit. The standard Model SPA-10 Tuning Head

TABLE 1-1. ACCESSORY KIT COMPONENTS

ITEM NO.	COMPONENT	PART NO.	QUANTITY
1	Waveguide Connector WR (62) to WR (42) tapered transition	556019-172	1
2	Waveguide Connector WR(62) to WR(28) tapered transition	556026-314	1
3	Attenuator jumper cable	556023-106	1
4	Alignment tool	556005-028	1
5	Alignment tool	556005-032	1
6	Alignment tool	556005-038	1
7	Spline key	556005-011	1
8	Spline key	556005-012	1
9	Spline key	556005-013	1
10	Spline key	556005-026	1
11	Hexagonal key	556005-122	1
12	Hexagonal key	556005-123	1
13	Hexagonal key	556005-124	1
14	Hexagonal key	556005-125	1

converts incoming signals within the 10MC to 43 KMC band to the 160 ±40 megacycle first IF (acceptance slot) of the Indicator Unit which displays the signals on the screen of a medium persistence CRT as vertical deflections distributed horizontally in order of frequency.

1-14. TUNING HEAD. Incoming signals are received through one of the two RF INPUT receptacles on the front panel of the Tuning Head. External waveguide-to-coax adapters are provided as standard accessories to permit suitable connection. Signal levels as high as 250 microvolts (-40 dbm) may be connected directly; signals in excess of this level must be attenuated prior to insertion to prevent overload and possible damage to the input mixers. Limited band tuning heads are furnished when specified.

1-15. An internal 0-100 db dual-range variable attenuator provides RF attenuation for signals in the frequency range from 10 megacycles to 12 gigacycles. When RF attenuation in this range is desired, the input signal is connected to the applicable 10MC-1KMC or 1-12 KMC ATTEN INPUT receptacle. Within the Tuning Head the signal is attenuated to the degree selected by the RF ATTENUATOR control and reappears at the corresponding ATTEN OUTPUT receptacle. Dial calibrations are for reference only and do not represent actual levels in db.

1-16. An accessory jumper is furnished to connect the attenuated signal to the applicable RF input receptacle. In addition any external 50 ohm calibrated RF attenuator with adequate frequency response can be used, either separately or in conjunction with the internal system. Since signals above 12 gigacycles are beyond the range of the internal system, an external attenuator must be used to reduce high signal levels at these frequencies.

1-17. The local oscillator frequency is selected by a relay network from among the fundamental and harmonic outputs of a triode oscillator and a reflex klystron. The oscillator for the first two bands is a triode with a tuned transmission

line. The first band is covered by the fundamental and the second band by the third harmonic.

1-18. The oscillator used for higher frequencies is a reflex klystron. The third band is covered by the fundamental, and the three highest bands are covered by the second, fourth, and seventh harmonics respectively. Klystron power is maintained at a high level to provide superior harmonic output and uniform power across each band.

1-19. Both local oscillators are gang-tuned by a common mechanism coupled to the Tuning Dial pointer and actuated by the TUNING control. The triode is tuned by varying the effective length of a circular transmission line with a sliding short. The klystron is tuned by a movable cavity short with a tracked repeller voltage. Oscillator output is precisely matched to dial calibration by means of an adjustable cam so that the indicated number on the illuminated tuning dial band represents the exact center of the scanned spectrum segment.

1-20. The selection of the proper oscillator-mixer combination is determined by the setting of the RANGE switch which actuates a relay switching network and illuminates the desired tuning dial band. The switching network also connects the input signal and the selected oscillator output to the selected coaxial mixer for heterodyne conversion.

1-21. The input mixer used above 12 gigacycles is a custom designed, low-loss, coupled-coax line located directly behind the front panel. This mixer provides a high conversion efficiency and high sensitivity to permit ready analysis of weak and short pulsed signals.

1-22. The output from the selected first mixer is fed to a two-stage, grounded-grid IF preamplifier with a bandpass of 160 ±40 megacycles (corresponding to maximum sweep width). This preamplifier is located in the Tuning Head to minimize cable losses and provide maximum sensitivity.

1-23. INDICATOR UNIT. The first IF signal from the Tuning Head is fed to the grid of a second wideband, two-stage, grounded-grid amplifier. Here it is joined by the output from the marker oscillator circuit and the amplified composite signal is connected to a second mixer. The mixer is driven by a swept oscillator with a center frequency of 235 megacycles. Oscillator sweep is continuously variable from ±100 kilocycles to ±40 megacycles about the center frequency by means of a front panel control.

1-24. Within the second mixer, the combined signal (input plus marker) is heterodyned with the swept oscillator output to produce the 75±3 megacycle second IF frequency. This signal is fed through an IF bandpass filter to a switch-controlled attenuator network providing from 0 to 40 db of signal attenuation. The attenuator output is amplified through the two-stage, pentode, second IF amplifier and applied to the third IF mixer. The gain of the second IF amplifier is adjusted by a continuously variable front panel attenuator control.

1-25. In the third IF mixer, the signal is heterodyned with the 68.5 megacycle output of a third local oscillator to produce the 6.5 megacycle third IF frequency which is amplified through three stages and applied to an AM detector. The IF bandwidth of this amplifier section is determined by the setting of a front panel control which adjusts two ganged potentiometers to vary the IF bandwidth from 1 to 80 kilocycles. Two quartz-crystal, series-resonant filters are also provided in this circuit to improve signal resolution and skirt selectivity.

1-26. The peak diode AM envelope detector normally provides a linear amplitude response. When a logarithmic response is desired, a front panel selector switch returns a portion of the detected signal to the final stage of the third IF amplifier as degenerative feedback. This feedback signal serves to vary the gain of this stage and compress the deflection vs input level curve into a log scale with a 100 to 1 (40 db) usable ratio. Similarly, when a power scale amplitude is desired, the selector switch returns a portion of the signal as regenerative feedback to provide a square law characteristic. The detected signal is then fed through an adjustable low pass filter, amplified to the required level, and applied to the vertical deflection plates of the CRT.

1-27. The front panel contains the usual controls for regulating the position, brightness, and clarity of CRT signals. Sweep rate, sweep width, and sweep synchronization controls are also provided to enable the operator to obtain a stable, well-defined signal.

1-28. ELECTRICAL CHARACTERISTICS.

1-29. SPECIFICATIONS. Analyzer specifications are listed in table 1-2 and described in paragraphs 1-30 through 1-48. Specifications applicable to individual frequency bands are listed in table 1-3.

TABLE 1-2. SPECIFICATIONS

PARAMETER	SPECIFICATION
Frequency Range	10 MC to 43 KMC in six bands
Sweep Width	a. 200 KC to 5 MC for input frequencies from 10 MC to 100 MC b. 200 KC to 80 MC (optional to 100 MC) for input frequencies from 100 MC to 43 KMC
RF Attenuation	a. A 100 db variable RF attenuator is provided for bands 1 through 4 (10 MC to 12 KMC). b. External waveguide RF attenuators for bands 5 and 6 (12 to 43 KMC) are available. (Refer to table 1-1.)
Frequency Accuracy	Scale calibrations are accurate to ±1% or ±1 MC, whichever is greater.
IF Bandwidth	Adjustable from 1 KC to 80 KC
IF Attenuation	a. Switches: 0 to 40 db in 1 db steps. Accuracy is 0.05 db per db. b. Vernier: 0 to 20 db smooth control.
Maximum Input Levels (To avoid overload distortion)	-40 dbm into direct input connector
Display Facilities	5-inch medium persistence CRT (5ADP1) furnished; high persistence CRT (5ADP7) available. Oscilloscope camera-mounting bezel, adjustable scale illumination, and calibrated graticule engraved on reverse side for minimum parallax are provided.
Amplitude Measurement	Linear, 40 db Logarithmic, and Power (Square Law) Scales.
Sweep Repetition Rate	Continuously variable from 1 to 60 cps. Free running or synchronized to line or external source. On calibration setting, line frequency wave appears on CRT screen for visual sweep rate calibration and synchronization with line frequency.
Frequency Markers	a. VFO for sweep width calibration has calibrated scale from -40 to +40 megacycles. The scale has divisions every 2.5 megacycles with an incremental accuracy of ±500 kilocycles. b. Marker modulation input frequencies from 10 kilocycles to 10 megacycles supplied by an external signal generator can be used for simultaneous sideband marker pip presentation on either side of the internal marker oscillator pip. Frequency spacing of calibrated marker pips is determined by the signal generator. c. Optional crystal controlled frequency markers (0.01% accuracy) every 1, 10, and 100 megacycles are available upon request for checking frequencies to 12 KMC.
Power Requirements	115/230 VAC, single phase, 50-60 cycle. Power consumption is approximately 400 watts.

TABLE 1-3. FREQUENCY BAND SPECIFICATIONS

BAND	FREQUENCY RANGE	TUNING HEAD OSCILLATOR FREQUENCY	SENSITIVITY (Note 1)	INPUT TERMINATION (50 ohms)
1	10-680 MC	Triode-Fundamental	-95 to -105 dbm	Type N
2	600-2360 MC	Triode-3rd Harmonic	-85 to -95 dmb	Type N
3	2200-6040 MC	Klystron-Fundamental	-90 to -100 dbm	Type N
4	4640-12,240 MC	Klystron-2nd Harmonic	-80 to -95 dbm	Type N
5	12-18 KMC	Klystron-4th Harmonic	-70 to -85 dbm	UG-419/U
5-6	18-26.5 KMC	Klystron-4th & 7th Harmonics (Note 2)	-60 dbm (nominal)	UG-595/U (Note 3)
6	26.5-43 KMC	Klystron-7th Harmonic	-50 dbm (nominal)	UG-599/U (Note 3)

NOTES:

1. Rated at a 2:1 signal-to-noise ratio. Best sensitivity is obtained with narrow band scans and high selectivity (near minimum IF bandwidth).
2. The 4th harmonic of the Klystron frequency is used from 12 to 24 KMC; the 7th harmonic is used from 24 to 43 KMC.
3. Adapters are furnished for these terminations.

1-30. FREQUENCY RANGE. The analyzer covers the frequency range from 10 MC to 43 KMC in six bands. (For the tuning ranges of individual bands, refer to table 1-3.) Tuning is accomplished using a slide rule dial with six individually calibrated scales. Dial accuracy is better than ±1% or one megacycle, whichever is greater. When the desired frequency band is selected, the corresponding dial scale is automatically illuminated.

1-31. FREQUENCY MARKERS. An adjustable frequency marker, supplied by the marker generator circuit, is used to determine sweep width limits, measure the frequency differential between displayed signals, and establish the width of broad spectrum signals. The marker is continuously variable within ±40 megacycles of the center frequency with an accuracy of ±5% of the maximum display. Marker level is adjustable with a front panel control.

1-32. Markers of greater accuracy can be obtained using external marker modulation provided by a precision signal generator. Accuracy of the marker frequency is then limited only by the quality of the external generator. In addition, an internal crystal calibrator, available as an option, can provide markers at 1, 10, or 100 megacycle intervals with an accuracy of ±0.01% for maximum precision. (Refer to paragraph 1-53.)

1-33. SENSITIVITY. The certified minimum analyzer sensitivity listed in table 1-3 is rated at a 2:1 signal-to-noise ratio. Best analyzer sensitivity is obtained with a narrow IF bandwidth since noise level is reduced in proportion to the square root of the IF bandwidth. When the IF bandwidth is reduced below optimum, however, the signal is degraded more rapidly than the noise.

1-34. RESOLUTION. Resolution describes the analyzer's ability to separate closely spaced discrete (CW) signals to permit the study and measurement of their frequency and levels. This ability is basically a function of IF bandwidth and scan velocity. For a given IF bandwidth, maximum resolution may be computed in accordance with the following formula:

$R = 1.3 \sqrt{DT}$ Where R = resolution (cps)
D = sweep width (cps)
T = sweep rate (cps)

1-35. Since best resolution requires a minimum value for R, it is apparent that both the sweep width (D) and the sweep rate (T) should be adjusted for the minimum level consistent with the desired display. In normal practice this computation is seldom made. Instead, a fairly wide sweep width is used to aid in locating the desired signal. When the signal has been located and centered on the screen, the sweep width is then reduced to provide maximum resolution.

1-36. IF BANDWIDTH. The IF bandwidth is also important in defining the analyzer's performance particularly in plotting envelopes of essentially continuous signal distributions as with pulsed signals and ramdom noise energies. To achieve optimum resolution, the IF bandwidth should be set to a little less than the calculated resolution. If the IF bandwidth is too narrow, excess ringing, signal attenuation, and excessive pip width are produced; if too wide, the resolution approaches the IF bandwidth and is poorer than optimum. In practice, IF bandwidth is adjusted for the best visual resolution with the specific sweep width and sweep rate selected. The IF bandwidth is continuously variable from 1 to 80 kilocycles with a front panel control.

NOTE

A limiting factor in analyzer resolution may be the internal FM generated by the local oscillators of a spectrum analyzer. When this FM is comparable with the IF bandwidth, it reduces resolution capability. Residual FM causes a horizontal smear of signal indications appearing as signal jitter. The model SPA-10 has been specially engineered for a low internal FM level and, in properly operating equipment, FM jitter is negligible.

The tuning bands which use the klystron oscillator are most likely to be limited by such internal FM. On Model SPA-10 units equipped with phase lock terminals, an oscillator synchronizer can be used to stabilize the klystron local oscillator to a crystal-controlled reference. (Refer to paragraph 1-59.)

1-37. OVERLOAD. The maximum input level to the Tuning Head mixer which provides a linear response minus the analyzer sensitivity at the signal frequency represents the usable amplitude dynamic range. This is the range over which the analyzer is linear and where the greatest ratio of relative signal level can be accurately measured. Injection of signals stronger than the overload point results in indicator errors due to distortion. Sufficiently strong signals can cause the input mixers to block with no response or even burn out. The maximum input level for a linear response (overload point) is -40 dbm at the INPUT 10 MC-12 KMC or DIRECT INPUT 12-43 KMC receptacles and -25 dbm at the 10MC-1KMC and 1-12 KMC ATTEN INPUT receptacles when the RF ATTENUATOR control is set for minimum attenuation.

NOTE

Stronger signals, up to 0 dbm, may be inserted at the direct input receptacles for limited dynamic range tests such as the examination of the major lobes of a pulsed signal.

1-38. SWEEP WIDTH. The sweep width (dispersion) is the frequency span of the spectrum segment displayed on the CRT and represents the swing of the swept oscillator. Very wide sweep widths are useful in locating and identifying signals, particularly short pulses, which produce very broad spectra. The analyzer permits the measurement of such signals in a small fraction of the time required by point-to-point techniques. Reduced (narrow) scans permit detailed inspection of a highly resolved narrow band. Narrow band analysis is frequently necessary for the study and measurement of AM and FM sideband modulation characteristics, and in the separation and measurement of closely spaced signals in general. (See figure 1-2.)

Figure 1-2. Bandwidth vs Sweep Width

1-39. SWEEP RATE. The sweep rate is the frequency (in cps) with which the electron beam moves across the CRT screen. This rate is determined by the frequency of a sawtooth signal (produced in the sweep generator circuit of the analyzer) which causes the output of the swept oscillator to track with the CRT sweep. Sweep rate is controlled by varying the natural resonance of the sweep generator circuit and is continuously adjustable from 1 to 60 cps by means of a front panel control.

1-40. SWEEP SYNCHRONIZATION. Without some form of synchronization, the sweep generator is essentially free running. Since some time reference is generally desirable, provision is made for three methods of sweep synchronization (line, external, and calibrated) selected by a front panel control.

1-41. Line synchronization is obtained by coupling a portion of the line frequency into the sweep generator. Because the most commonly used sweep rates range from 10 to 60 cps, a convenient source for sweep synchronization is the 60 cps line frequency. Not only is this frequency a relatively accurate reference, but it is the most common source of residual frequency modulation in most equipment. Since the triggering of the horizontal sweep is then synchronized to some function of the hum frequency, the hum modulation is effectively "stopped".

NOTE

When it is desired to monitor line modulation, it is apparent that the use of line synchronization will mask the desired data. Accordingly, free running operation or external synchronization must be used.

1-42. External synchronization, connected through a front panel receptacle, can be used with pulse signals to lock the sweep rate to the pulse repetition rate, providing a stationary pattern of the sampled pulses. It can also be used to examine the quality of individual pulses for jitter and other irregularities. The pulse repetition rate may be measured by counting the lines in a known sweeptime interval.

NOTE

When it is desired to monitor pulse modulation, it is apparent that the use of signal synchronization will mask the desired data. Accordingly, either line synchronization or free running operation must be used.

1-43. The sweep circuit may be calibrated against the line frequency by applying the line frequency to both the sweep generator and the CRT vertical deflection plates. A distorted sine wave appearing at the lower part of the CRT screen indicates that the sweep circuits are properly synchronized. (See figure 5-1.) This distortion is the result of a special line filter designed to limit undesired spurious frequencies within the analyzer. Only the calibration sine wave is affected by this filter and no distortion is apparent in other operating modes.

1-44. SIGNAL INPUT CONNECTORS. Type N coax-to-coax connectors are required for the 10 MC — 12 KMC INPUT and the 10 MC — 1 KMC and 1 — 12 KMC ATTEN INPUT and ATTEN OUTPUT receptacles. Coax-to-waveguide adapters are required to connect signal inputs above 12 KMC to the 12 — 43 KMC DIRECT INPUT receptacle. At high frequencies these waveguide inputs sharply attenuate unwanted frequencies below cutoff (as in harmonic products measurement) thus providing considerable preselection.

1-45. AUXILIARY INPUT RECEPTACLES. Provision is made for the insertion of an external sweep synchronization signal through the EXT SYNC receptacle. Marker modulation from an external signal generator can be applied through the MARKER MOD receptacle.

1-46. AUXILIARY OUTPUT RECEPTACLES. Receptacles for X, Y, and Z axis outputs and provisions for klystron phase locking with an external oscillator synchronizer are available as equipment options. Phase locking is especially useful in providing jitter-free narrow band analysis.

NOTE

Captive covers are supplied for all front panel receptacles. These covers should be securely fastened to receptacles not in use to prevent stray signal radiation spurious pick-up.

1-47. POWER REQUIREMENTS. Nominal equipment power is 115/230 VAC, single phase, 50-60 cycle with an approximate power consumption of 400 watts. The analyzer is normally wired for 115 VAC operation unless otherwise specified.

1-48. TUBE COMPLEMENT. The equipment tube complement is listed in table 1-4.

TABLE 1-4. TUBE COMPLEMENT

REF. DESIG.	TYPE	FUNCTION
	TUNING HEAD	
V201	6AF4A	Local Oscillator 170-840 MC
V203	5842	Preamplifier — First Stage
V206	5842	Preamplifier — Second Stage
V207	6BL6	Local Oscillator 2400-6000 MC
	INDICATOR	
V101	6650	Regulator
V102	6650	Regulator
V103	6650	Regulator
V104	12AX7	DC Amplifier
V105	0G3	Reference Tube
V106	12AX7	DC Amplifier
V107	0A2	Voltage Regulator
V108	6550	Series Regulator
V109	6AH6	DC Amplifier
V110	0D3	Voltage Regulator
V111	0D3	Voltage Regulator
V112	0D3	Voltage Regulator
V113	0D3	Voltage Regulator
V114	6BQ5	100 KC Oscillator
V301	5842	Amplifier
V302	5842	Amplifier
V303	6AF4A	Mixer
V304	12AX7	AGC Amplifier
V305	6AQ5A	AGC Amplifier
V306	6AW5A	Sawtooth Driver
V307	6AF4A	Swept Oscillator
V401	6AF4A	Marker Oscillator
V601	6688	Amplifier
V602	6688	Amplifier
V603	6J6	Mixer
V604	6AB4	Cathode Follower
V605	6CB6	6.5 MC Amplifier
V606	6AB4	Cathode Follower
V607	6CB6	Amplifier
V608	6AH6	Amplifier
V609	6AL5	Detector
V610	7699	Vertical Amplifier
V611	12AU7	Instensifier
V612	6CB6	Blanker
V701	5ADP1	Cathode Ray Tube
V801	12AT7	Sync Amplifier
V802	6CB6A	Sawtooth Generator
V803	6AB4	Cathode Follower
V804	12AU7	Horizontal Amplifier

1-49. MECHANICAL CHARACTERISTICS.

1-50. PHYSICAL DIMENSIONS. The physical dimensions of both the cabinet and rack-mounted models are listed in the following tabulation. Outline dimensions of the rack-mounted model are also shown in figure 2-1.

MODEL	DIMENSIONS
Cabinet-SPA-10 (See figure 2-1.)	19-7/16 inches high, 17-9/16 inches wide, 19-1/8 inches deep (Add 1-9/16 inches for front panel hardware.)
Rack-Mount — SPA-10R (See figure 2-1.)	22-15/16 inches high (including 3-1/2-inch mounting tray), 18-15/16 inches wide (including two 11/16-inch dress strips), 19-1/8 inches deep. (Add 1-9/16 inches for front panel hardware.) Slide length is 17-7/8 inches; travel is 21-1/2 inches.

1-51. WEIGHT. Equipment weight is approximately 110 pounds.

1-52. OPTIONAL EQUIPMENT.

1-53. CRYSTAL CALIBRATOR. An integral crystal calibrator, available as an option, provides fixed frequency, crystal-controlled marker pips accurate to 0.01% at 1 MC, 10 MC, or 100 MC intervals selected by means of a front panel control.

1-54. The calibrator consists basically of three crystal-controlled oscillators actuated by the R. F. CAL. switch. When the switch is in the OFF position, the B+ voltage is removed from the calibrator and none of the oscillators is operative. When the switch is placed in the 1 MC, 10 MC, or 100 MC position, the analyzer is automatically switched to narrow-band operation (200 KC — 5 MC sweep width) and plate voltage is applied to the selected oscillator tube.

1-55. The fundamental and harmonic output from the 1 MC or 10 MC oscillator is applied to the coaxial mixer (Z201), while the output from the 100 MC oscillator is applied to either the coaxial mixer (Z201) or the waveguide mixer (Z302). Since the RANGE switch position determines which mixer output is fed to the IF amplifiers, it is apparent that, while the R.F. CAL. switch position controls the frequency of the pip produced, the position of the RANGE switch determines whether the selected pip will appear on the screen. Accordingly, 1 MC and 10 MC marker pips can be used only when the RANGE switch is in the 10 MC — 1 KMC position. Similarly, the 100 MC marker pips are usable only when the RANGE switch is in 3-12 KMC and 12-43 KMC position.

1-56. Because the sweep width is limited by narrow-band operation to a maximum of 5 MC, it is apparent that no more than six 1 MC nor more than one 10 MC or 100 MC pips can appear on the screen at one time. Accordingly, it is relatively easy to identify the frequency of a particular pip.

1.57. Since the calibrator makes use of oscillator harmonics, some reduction in pip amplitude at higher frequencies is to be expected. The LEVEL control permits the operator to compensate for this by adjusting the amplitude of the 1 MC and 10 MC pips. This control does not affect the 100 MC oscillator output, which is provided with an additional amplifier stage to ensure adequate pip amplitude.

1-58. 100 MEGACYCLE SWEEP WIDTH. An expanded sweep width with a range from 200 KC to 100 MC is available as an equipment option. This provision provides an increase of 20 MC in the maximum spectrum scan over the 80 MC limit afforded by the standard analyzer.

1-59. KLYSTRON PHASE LOCKING. Suitable receptacles and modified internal analyzer circuitry are available to permit the use of an external oscillator synchronizer to correct for jitter or drift in the klystron output signal. Specifications for this option are listed in the following tabulation:

PARAMETER	SPECIFICATION
Sampled Klystron Frequency Range	2.36 — 6.26 KMC
Synchronized Analyzer Frequency Range	2.2 -- 43.0 KMC
Incidental IF FM*	Less than 2.0 KC
Sample RF Output Power	0.1 MW Minimum
FREQUENCY Output Receptacle	Type N
REPELLER Input Receptacle	Cannon Type RWK-5-31/SL
Safety Interlock	Yes
Location of Receptacles	Front panel
Suitable synchronizers (typical)	Dymec 2650A, Dymec 2654A, or LFE 242

*When used with the analyzer, the synchronizer increases the stability of the analyzer to the basic stability of the second IF (swept) oscillator in the analyzer.

1-60. The modified analyzer is supplied with two additional receptacles marked FREQUENCY and REPELLER. The FREQUENCY receptacle is connected to the oscillator synchronizer input receptacle and supplies a sample of the klystron output signal. Within the synchronizer, the klystron signal is mixed with the output of a harmonic generator. The difference frequency (usually 30 MC) is then amplified, limited, and compared against a standard (again usually 30 MC) in a phase discriminator.

1-61. Any frequency shift is sensed by the phase discriminator which produces a DC voltage proportional in polarity and amplitude to the direction and degree of the klystron drift. This DC voltage is returned to the analyzer through the REPELLER receptacle and connected in series with the klystron repeller voltage. Accordingly, any drift in the klystron frequency is sensed by the synchronizer which provides the feedback necessary to return the klystron to its proper frequency.

1-62. For operation of the synchronizer, a shorting plug is provided which connects the repeller and anode of the klystron to their respective power supplies. Note that either the synchronizer or the shorting plug must be connected in order to operate the analyzer since a jumper path is required for the klystron high voltage circuits.

1-63. Additional detail parts supplied with the modified analyzer are listed in the following tabulation:

NOMENCLATURE	PART NO.
Panel Receptacle (REPELLER)	556016-345
Mating Connector	556016-346
Panel Shorting Plug	556016-344
Shorting Plug Cap	556016-347
Panel Receptacle (FREQUENCY)	556128-086
RF Receptacle Cap and Chain	556016-096
Klystron Output Probe	556161-029

1-64. XYZ OUTPUT. Convenient front panel receptacles for XYZ outputs are available as a standard option. The receptacles permit the operator to monitor analyzer signals using an oscilloscope or a suitable recording device. The X-axis (horizontal) signal is sampled at the grid of the horizontal amplifier and fed to the HORIZ (horizontal) receptacle J285 on the front panel of the analyzer.

1-65. The Y-axis VERT (vertical) receptacle J255 is in parallel with the CRT vertical deflection plates, while the Z-AXIS (intensity modulation) receptacle J279 samples the signal at the CRT grid. This option entails minor changes to the front panel, wiring modifications, and the inclusion of the three receptacles, Part No. 556010-092.

1-66. MULTIPULSE DECODER. The Multipulse Decoder, Model MPD-1, is offered as an optional accessory to be used in conjunction with the analyzer. The decoder permits the selection of one or more pulses from a larger train of pulses and couples the desired signal to the analyzer. This device consists basically of three wideband IF amplifiers, a gating circuit, a coaxial switch, a detector, and a power supply. Operating and maintenance instructions for this instrument are provided in a separate manual supplied with the decoder. Note that the decoder requires access to the 160 MC first IF frequency. This requirement is readily met with the inclusion of the IF INPUT-OUTPUT receptacle option described in the following paragraph.

1-67. IF INPUT-OUTPUT. Access to the 160 MC first IF signal is available at the optional IF INPUT-OUTPUT receptacles located on the front panel. These receptacles are inserted in series between the output of the 160 MC preamplifier and the wideband amplifier circuit and permit the first IF signal to be monitored and/or modified by external devices. The receptacles must be connected by the short jumper supplied to maintain circuit continuity when no other equipment is connected. This option includes the incorporation of two receptacles. Part No. 556010-092.

1-68. POLAROID CAMERA ASSEMBLY. The Polaroid Oscilloscope Camera Assembly, Model SM-200A, is available as an accessory complete with mounting facilities and is suitable for attachment to any CRT device provided with a 5-3/8 inch O.D. bezel. The camera features a Wollensak f:1.9, 75 m.m. coated anastigmat lens and provides full size screen prints without mirror reversal. Lens aperture and shutter speed are fully adjustable without removing the camera from the analyzer. A monocular viewer permits final adjustment of the CRT display before shooting.

SECTION 2

INSTALLATION

2-1. UNPACKING AND INITIAL INSPECTION.

2-2. Equipment components have been inspected prior to shipment and carefully packed to prevent damage while in storage or transit. Use caution in unpacking and handling this equipment to prevent damage from impact or exposure to the elements.

2-3. When unpacking, check the contents of all containers against the Equipment Supplied data provided in this manual (paragraph 1-7) and the packing slip to ensure that all components have been accounted for. Check that all tubes and other plug-in components are well-seated in their sockets. The analyzer has been thoroughly tested and calibrated before shipment and only minor preparations are required to put this instrument in operation.

2-4. INSTALLATION PROCEDURES.

2-5. EQUIPMENT LOCATION. This equipment should be located in a clean-well-ventilated area where ambient light is not excessive. For adequate cooling, provide a 7-inch clearance behind the unit; restricted airflow may cause overheating.

2-6. CABLE CONNECTIONS. The equipment is supplied with an integral power line cord which should be connected to a suitable source of AC power. (For equipment power requirements, refer to paragraph (1-47). When the equipment is not in use, this line cord should be stored in the recessed compartment located at the rear of the equipment. An attenuator jumper cable is also included as an accessory item. All other cables are located inside the equipment and are factory-connected prior to shipment.

2-7. OUTLINE DIMENSIONS. The outline dimensions for both the cabinet and rack-mount models are listed in paragraph 1-50.

2-8. INSTALLATION – RACK-MOUNT MODEL. The rack-mount version of the analyzer consists of a standard cabinet model and the following additional components.

NOMENCLATURE	PART OR MODEL NO.
Mounting Tray Assembly	Model RM-1a
Dress Strips (Set of 2)	Part No. 556162-579
Retainers (Set of 2)	Part No. 556162-580
Non-Tilt Slide Assembly	Part No. 556001-354

2-9. To install the rack-mount model in a standard RETMA rack, perform the following steps:

a. Fasten one of the small slide brackets to the rear of each slide rail using the screws and bar nuts supplied with the slide assembly. (See figure 2-1.)

b. Fasten each of the slide rails to the front and rear flanges of the rack using the hardware provided. Note that if the rack is provided with 10-32 threaded holes, the bar nuts are not required. Check that the rails are level and at the same height.

c. Extend the slide rails to their maximum length and note that they lock in place.

d. Position the analyzer so that the mounting tray tracks are aligned with the slide rails extending from the rack. Insert the tracks into the slide rails and slide the analyzer into the rack. The latching locks (figure 2-1) will have to be manually raised to permit complete closure.

CAUTION

Because of the weight of the analyzer, step d requires the efforts of two men.

e. Attach the dress strips and retainers as shown in figure 2-1.

2-10. POWER CONVERSION. The analyzer is normally wired for 115 VAC operation unless otherwise specified. To convert the equipment to or from 230 VAC operation, see figure 2-2.

2-11. INSTALLATION CHECKS AND ADJUSTMENTS. Prior to operating the analyzer for the first time or immediately following the replacement of parts, perform the Minimum Performance Standards Checks listed in paragraphs 5-8 through 5-28.

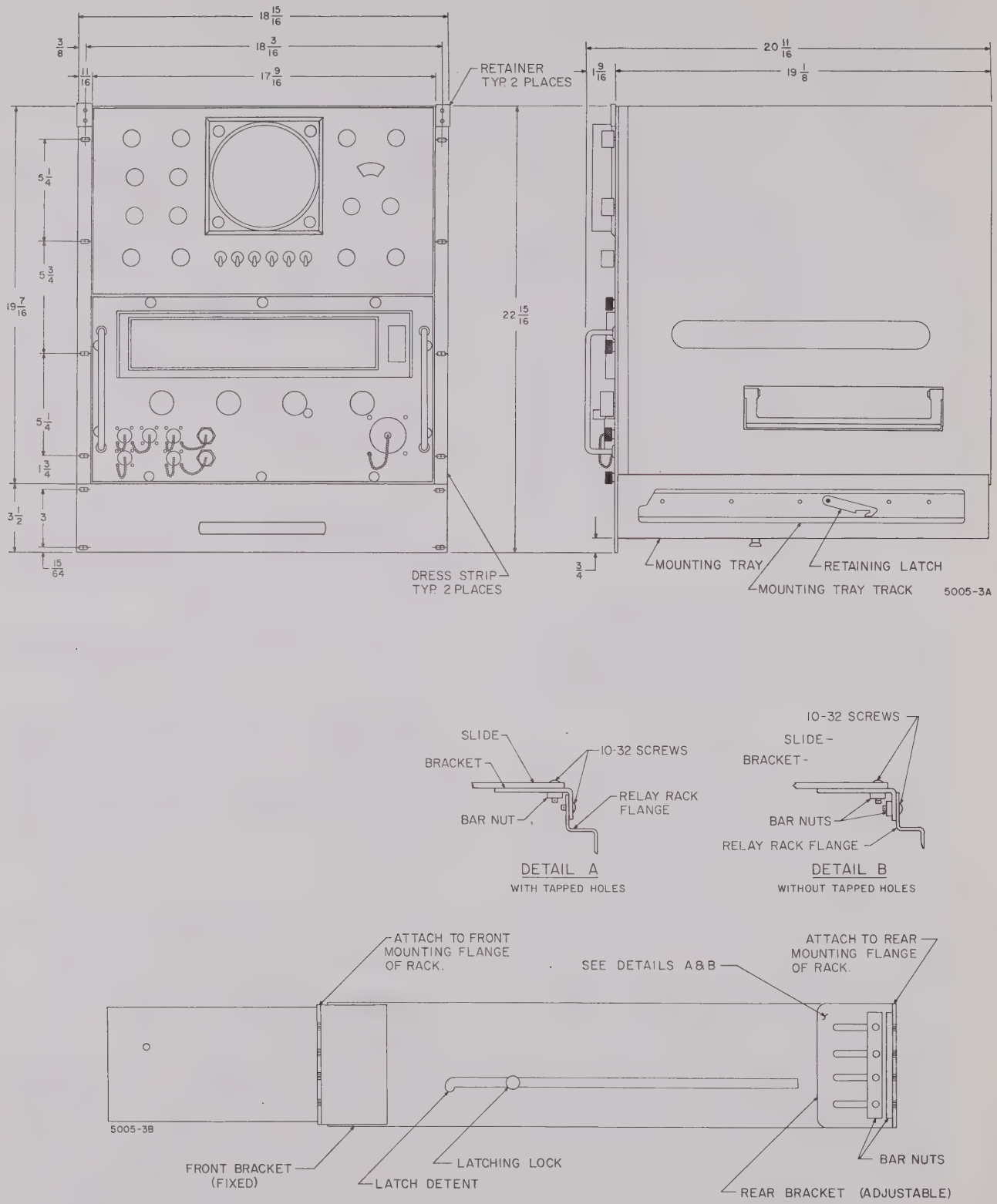


Figure 2-1. Outline Dimensions, Rack-Mounted Version

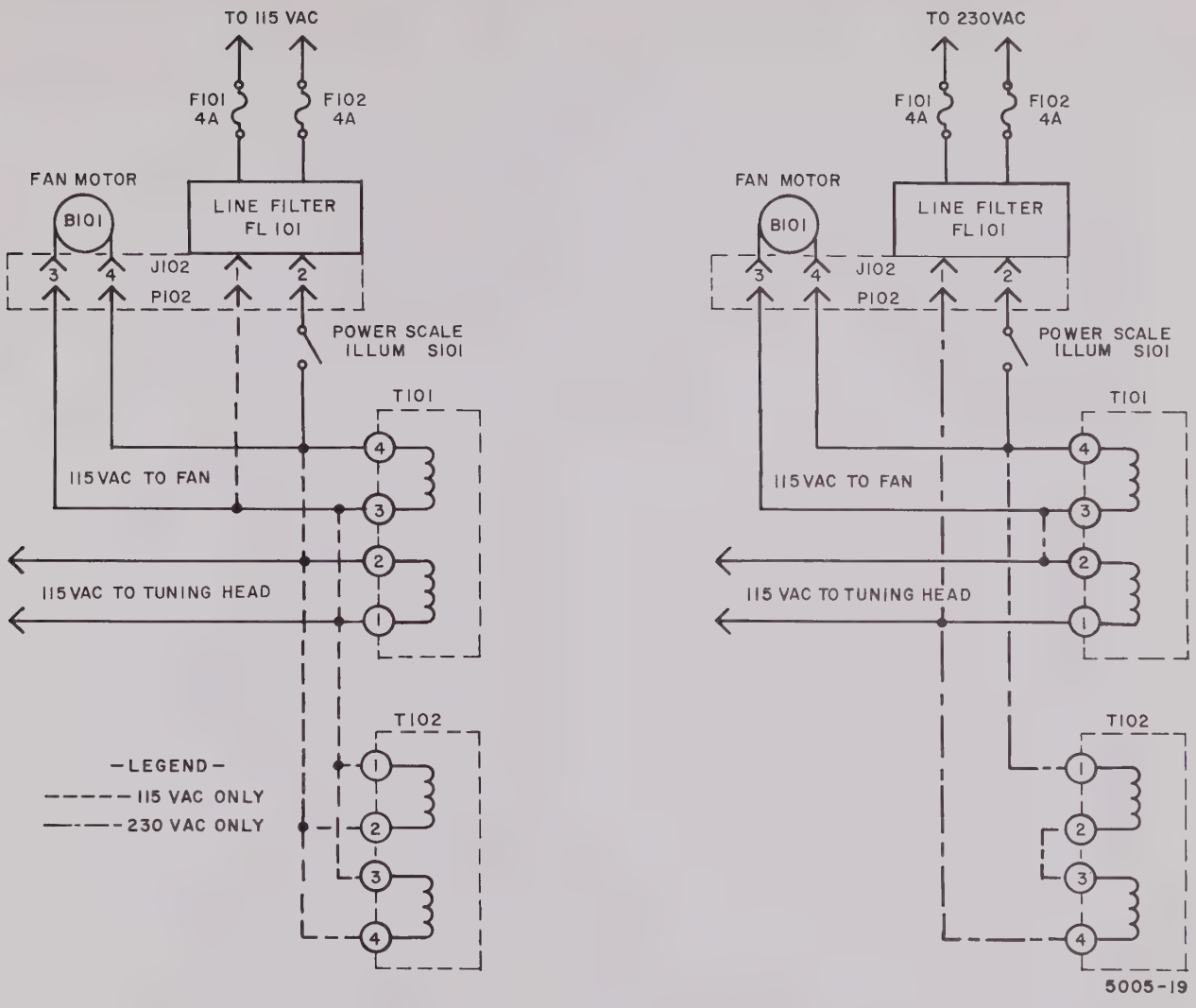


Figure 2-2. Power Conversion from 115 to 230 VAC, Schematic Diagram

SECTION 3

OPERATION

3-1. GENERAL.

3-2. This section of the manual describes the equipment operating and adjustment controls, operating procedures, and indicator presentations. Information is also provided to assist the operator in performing typical tests using the analyzer.

3-3. No attempt to use the analyzer should be made until the operator is thoroughly familiar with the information contained in this section.

3-4. OPERATING AND ADJUSTMENT CONTROLS.

3-5. Equipment operating and adjustment controls are listed in table 3-1 and illustrated in figure 3-1. Detailed information too lengthy to be included in tabular form is provided in subsequent paragraphs.

3-6. BRILLIANCE CONTROL. The BRILLIANCE control (1, figure 3-1) adjusts the intensity of the CRT display. At the full counterclockwise position, the CRT emission is reduced below the visible level (no apparent sweep). Rotating the control fully clockwise increases the brightness to maximum.

CAUTION

Do not use the BRILLIANCE control to compensate for a high level of ambient light. Excessive tube brightness prevents sharp signal focus and materially shortens the useful life of the CRT. Reduce the ambient light level or install a suitable screen shield.

3-7. CAL SYNC SEL SWITCH. The CAL SYNC SEL switch (2, figure 3-1) is a three-position, rotary switch controlling the CRT horizontal sweep synchronization. In the CAL position, it provides a 60 cps signal to the vertical input circuits to permit ready calibration of sweep rate. With the switch in the LINE position, the horizontal sweep is synchronized to the power line frequency, while in the EXT position, the sweep can be synchronized by a suitable signal connected to the EXT SYNC input receptacle (20).

3-8. SYNC AMPL CONTROL. The SYNC AMPL control (3, figure 3-1) adjusts the amplitude of the CRT horizontal sweep-synchronizing signal selected by the CAL SYNC SEL switch (2). This signal amplitude is increased as the SYNC AMPL control is rotated in a clockwise direction. In normal operation, this control is adjusted to provide only sufficient sync amplitude to stabilize the CRT screen presentation after the display has been tuned for minimum drift by the SWEEP RATE control (6).

NOTE

Excessive sync amplitude tends to shorten the baseline trace, adversely affecting CRT screen calibration. The optimum setting of the SYNC AMPL control is the minimum sync amplitude consistent with a stationary display.

3-9. CRT INDICATOR. The CRT indicator (4, figure 3-1) consists of a 5ADP1 cathode ray tube with an edge-lighted graticule. Signals displayed on the face of the CRT are viewed through the calibrated graticule which is engraved on the reverse side for minimum parallax error. For a description of the nature and function of graticule calibrations, refer to paragraphs 3-32 through 3-34.

3-10. When viewing the CRT screen, the operator should keep his sight directly in line with the center axis of the cathode ray tube at a distance of approximately 15 inches. (See figure 3-2.) Since screen calibrations are based on this viewing position; any deviation will introduce some degree of parallax error. A convenient method for finding the correct viewing position is to close one eye and obtain a reflection of the open eye at the exact center of the CRT screen.

3-11. POWER SCALE ILLUM CONTROL. The POWER SCALE ILLUM control (5, figure 3-1) is a dual-function switch-potentiometer. When turned slightly clockwise from the fully counter-clockwise position, this control applies AC power to the analyzer, illuminating one of the three pairs of Tuning Dial band calibrations. Switch engagement is indicated by an audible click. Further clockwise rotation of the control illuminates the graticule engraving on the CRT indicator (4). This lighting is increased to a maximum as the control is rotated fully clockwise.

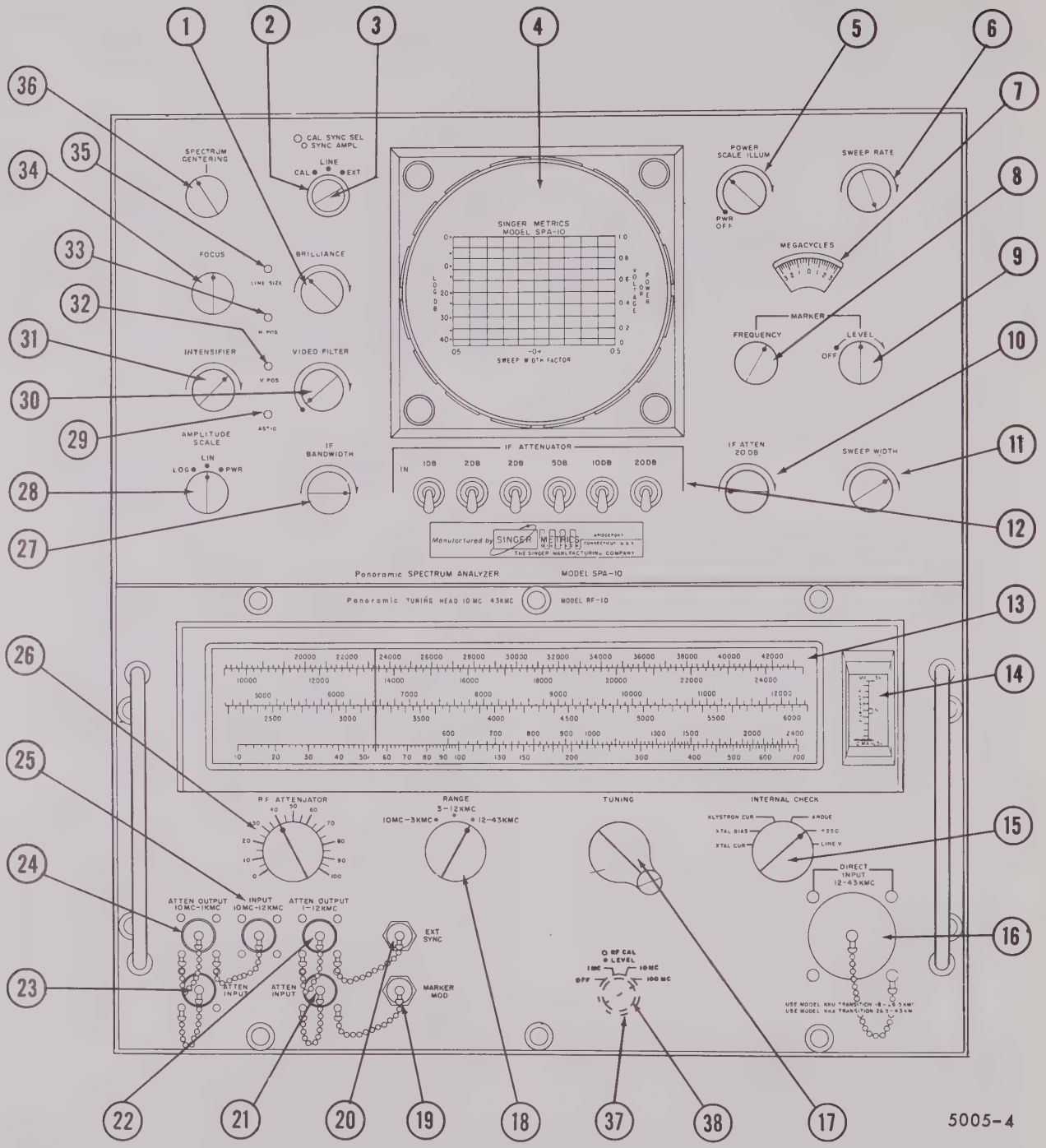


Figure 3-1. Front Panel — Operating and Adjustment Controls

TABLE 3-1. OPERATING AND ADJUSTMENT CONTROLS

INDEX NO. (Figure 3-1)	CONTROL	FUNCTION
1	BRILLIANCE control	Adjusts intensity of CRT display.
2	CAL SYNC SEL switch	Selects CRT horizontal sweep mode.
3	SYNC AMPL control	Adjusts amplitude of CRT horizontal sweep synchronizing signal.
4	CRT indicator	Displays line spectrum of signal and marker inputs.
5	POWER SCALE ILLUM – PWR OFF switch	Controls external line power and graticule edge-lighting.
6	SWEEP RATE control	Adjust CRT horizontal sweep rate from 1 to 60 cps.
7	MARKER dial	Indicates marker pip frequency variation from Tuning Dial pointer frequency.
8	MARKER FREQUENCY control	Positions marker pip on CRT screen within ±40 megacycles of Tuning Dial pointer frequency.
9	MARKER LEVEL control	Adjusts amplitude of marker pip.
10	IF ATTEN 20 DB control	Inserts from 0 to 20 DB of IF attenuation.
11	SWEEP WIDTH control	Adjusts sweep width (frequency span).
12	IF ATTENUATOR switches (6)	Insert from 0 to 40 db of IF attenuation in 1 db steps.
13	Tuning dial	Indicates selected band and frequency by scale illumination and movable pointer.
14	Internal Check Meter	Indicates system currents and voltages.
15	INTERNAL CHECK switch	Selects input to Internal Check Meter.
16	DIRECT INPUT 12-43 KMC waveguide receptacle	Accepts 12-43 KMC input signals.
17	TUNING control	Selects desired frequency within tuning range as indicated by pointer.
18	RANGE switch	Selects operating range of Tuning Head.
19	MARKER MOD input receptacle	Accepts external oscillator marker modulation input signals.
20	EXT SYNC input receptacle	Accepts external CRT horizontal sweep synchronizing signals.
21	ATTEN INPUT (1-12 KMC) input receptacle	Accepts and attenuates 1-12 KMC input signals.

TABLE 3-1. OPERATING AND ADJUSTMENT CONTROLS (Cont.)

INDEX NO. (Figure 3-1)	CONTROL	FUNCTION
22	ATTEN OUTPUT 1-12 KMC output receptacle	Provides external output tap for attenuated 1-12 KMC signals when input is provided to ATTEN INPUT (1-12 KMC) receptacle. (Jumper cable is provided).
23	ATTEN INPUT (10 MC – 1 KMC) input receptacle	Accepts and attenuates 10 MC – 1 KMC input signals.
24	ATTEN OUTPUT 10 MC – 1 KMC output receptacle	Provides external output tap for attenuated 10 MC – 1 KMC signals when input is provided to ATTEN INPUT (10 MC – 1 KMC) receptacle. (Jumper cable is provided).
25	INPUT 10 MC – 12 KMC receptacle	Accepts 10 MC – 12 KMC input signals below -40 dbm.
26	RF ATTENUATOR control	Provides from 0 to 100 db of RF attenuation (above initial insertion loss of 10 to 30 db). Used only in 10 MC – 1 KMC and 1 – 12 KMC ranges. Dial calibrations are for reference only.
27	IF BANDWIDTH control.	Adjusts bandwidth of third (6.5 MC) IF amplifier.
28	AMPLITUDE SCALE switch	Selects linear, logarithmic, or power (square law) amplitude presentation.
29	ASTIG Adjusting screw	Adjusts Indicator astigmatism circuit for uniform CRT focus.
30	VIDEO FILTER control	Adjusts suppression of unwanted video effects (e.g., noise and spurious beating between adjacent signals).
31	INTENSIFIER control	Adjust brightness of fast rise-time (pulsed) signals.
32	V POS adjusting screw	Adjusts CRT baseline in vertical direction.
33	H POS adjusting screw	Adjusts CRT baseline in horizontal direction.
34	FOCUS control	Adjusts visual sharpness of CRT display.
35	LINE SIZE adjusting screw	Adjusts length of horizontal baseline.
36	SPECTRUM CENTERING control	Adjusts tuning (vernier) to center spectrum on CRT screen.
37	RF CAL switch (Note 1)	Supplies B+ to crystal calibrator oscillators.
38	LEVEL switch (Note 1)	Controls level of 1 MC and 10 MC crystal calibrator markers.
NOTE:	1. These controls supplied only when the optional crystal calibrator is furnished.	

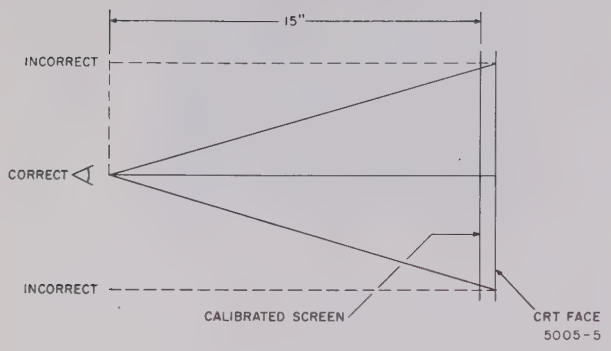


Figure 3-2. Correct Viewing Position

3-12. SWEEP RATE CONTROL. This SWEEP RATE control (6, figure 3-1) controls the frequency of the CRT indicator horizontal sweep, establishing a time base for the screen presentation. Minimum sweep rate is obtained when the control is fully counterclockwise. This control is normally adjusted in conjunction with the SYNC AMPL control (3) to provide a stable display synchronized to the reference signal selected by the CAL SYNC SEL switch (2).

3-13. MARKER DIAL. The MARKER dial (7, figure 3-1) is calibrated in 1/4 megacycle division from -40 to +40 megacycles. This dial indicates the variation in marker pip frequency above or below the tuning dial pointer frequency. Adjustment of the MARKER dial is made using the MARKER FREQUENCY control (8).

3-14. MARKER FREQUENCY CONTROL. The MARKER FREQUENCY control (8, figure 3-1) positions the marker pip horizontally along the CRT baseline. When the MARKER dial (7) is set at 0, the marker pip will appear at the center of the screen. As the control is rotated in the clockwise direction, the marker pip will move to the right and vice versa. The amount of frequency deviation from the Tuning Dial pointer position is indicated by the MARKER dial (7).

3-15. MARKER LEVEL CONTROL. The MARKER LEVEL control (9, figure 3-1) adjusts the amplitude of the marker pip appearing on the CRT screen. At the fully counterclockwise (OFF) position, no marker pip is produced. Rotating the control in a clockwise direction increases the marker pip amplitude. The MARKER LEVEL control is normally placed in the OFF position during search procedures and adjusted for the desired marker pip amplitude when accurate frequency measurements are required.

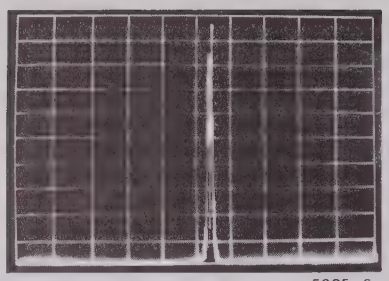
3-16. IF ATTEN 20 DB CONTROL. The IF ATTEN 20 DB control (10, figure 3-1) provides from 0 to 20 db of smooth, vernier IF attenuation. The attenuation obtained with this control is additive to the attenuation provided by the IF ATTENUATOR switches (12). Using both this control and the IF ATTENUATOR switches, it is possible to obtain any degree of IF attenuation from 0 to 60 db.

3-17. SWEEP WIDTH CONTROL. The SWEEP WIDTH control (11, figure 3-1) adjusts the frequency span of the CRT screen display. Normally, this span is adjustable from 200 kilocycles (±100 KC about the screen center) to 80 megacycles (±40 MC). (An expanded sweep width ranging from 200 KC to 100 MC is available as an option.) However, when the RANGE switch is in the 10 MC – 3 KMC position and the tuning dial pointer is between 10 and 100 megacycles, sweep width can be varied only from 200 kilocycles to 5 megacycles.

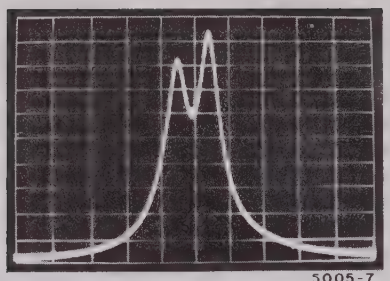
3-18. The SWEEP WIDTH control is used to select the frequency limits of the spectrum viewed by the CRT screen. These limits are established using the frequency marker pip and are usually set for the minimum sweep width consistent with the desired viewing range. At full sweep width, test signals or a carrier and its sidebands having a small frequency difference tend to have their adjacent deflections merge. (See figure 3-3a.) These deflections may be separated by reducing the sweep width. (See figure 3-3b.) Note that a reduction in sweep width provides increased pip amplitude and better sensitivity.

3-19. IF ATTENUATOR SWITCHES. The six IF ATTENUATOR switches (12, figure 3-1) provide IF signal attenuation from 0 to 40 db in 1 db increments when the required switches are placed in the IN (in-circuit) position. The attenuation provided by these switches is additive to the attenuation provided by the IF ATTEN 20 DB control (10).

3-20. TUNING DIAL. The tuning dial (13, figure 3-1) contains three dual-band range scales, one of which is illuminated for each position of the RANGE switch (18). Referring to figure 3-1, note that the bottom scale contains two sets of calibrations, the lower band ranging from 10 megacycles to 700 megacycles, the upper band ranging from 600 megacycles to 2400 megacycles. Accordingly, the maximum



a. Wide Sweep



b. Narrow Sweep

Figure 3-3. Improved Sensitivity Resulting from Reduced Sweep Width

tuning range of the scale is from 10 megacycles to 2400 megacycles. This scale is selected when the RANGE switch is in the 10 MC — 3 KMC position.

NOTE

The frequency ranges engraved at the RANGE switch position are nominal. Selection of RANGE position should be determined by the frequency range data provided by the tuning dial scales or listed in table 1-3.

3-21. The available frequency ranges provided by individual bands overlap somewhat so that the same frequency calibration may appear on more than one band. Note that on the bottom scale the 600 megacycle position appears on both the upper and lower bands. When monitoring frequencies which appear on more than one band, always tune to the lower frequency band. This selects the lowest oscillator harmonic and provides maximum sensitivity.

3-22. Within the illuminated scale, the tuning dial pointer indicates the exact frequency (within ±1% or 1 megacycle, whichever is greater) of the signal appearing at the center -0+ calibration line on the CRT screen.

3-23. For example, if the RANGE switch is set to the 10 MC — 3 KMC position, tuning dial bands 1 and 2 will be illuminated. Accordingly a signal appearing on the CRT screen will be within the frequency limits of these bands, and the frequency of the signal appearing at the center of the CRT screen will be indicated by the tuning dial pointer. Conversely, adjusting the TUNING control to place the tuning dial pointer at a specific frequency will place any input signal at that frequency at the center of the CRT screen. As the tuning dial pointer is moved from the low (frequency) to the high end of the scale, the signals travel across the CRT screen from right to left, appearing as vertical pips of varying amplitude. At any given time, the pip appearing at the center of the CRT screen indicates the frequency to which the Tuning Head is tuned.

NOTE

To determine the nature and frequency of an unknown signal, refer to paragraphs 3-46 through 3-58.

3-24. INTERNAL CHECK METER. The Internal Check meter (14, figure 3-1) is a 1 MA DC milliammeter connected to a metering circuit by the INTERNAL CHECK switch (15). This meter is used to monitor analyzer currents and voltages during operation and maintenance procedures.

3-25. INTERNAL CHECK SWITCH. The INTERNAL CHECK switch (15, figure 3-1) selects the input to the Internal Check meter (14). Switch positions and nominal meter readings are listed in table 5-3.

3-26. TUNING CONTROL. The TUNING control (17, figure 3-1) adjust the tuning dial pointer to the desired frequency. Final positioning of this control should always be performed in a counterclockwise direction for each new setting to eliminate mechanical backlash in the cable linkage.

3-27. RANGE SWITCH. The RANGE switch (18, figure 3-1) selects the desired frequency range of the analyzer, switches in the required Tuning Head circuitry, and illuminates the appropriate tuning dial scale. A description of switch function is provided in conjunction with the description of the tuning dial. (Refer to paragraph 3-20.)

3-28. IF BANDWIDTH CONTROL. The IF BANDWIDTH control (27, figure 3-1) varies

the bandwidth of the third (6.5 megacycle) IF amplifier stage. This control is used to resolve closely-spaced signals, improve the signal-to-noise ratio of low level signals, and improve the definition and brightness of pulse displays. Note that adjustment of this control to correct for the above conditions may cause the amplitude of the CRT presentation to vary.

3-29. Waveforms of figure 3-4 illustrate a progressive decrease in IF bandwidth with a corresponding decrease in pip width. The appearance of "ringing" in figure 3-4d indicates optimum signal resolution.

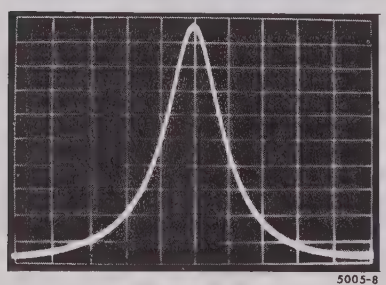
3-30. Accurate relative amplitude measurements of two adjacent signals can be made only when the two are properly resolved. This separation can be accomplished by the IF BANDWIDTH control. Waveforms of figure 3-5 a through e illustrate the progressive separation of closely spaced signals of equal amplitude as the IF bandwidth is narrowed.

3-31. When a low amplitude signal is close in frequency to a signal of large amplitude, the low amplitude signal pip will be influenced by the larger signal. As the signals are resolved by reducing the IF bandwidth, the signals separate and the undesired effect is reduced. Waveforms of figure 3-6 a through f illustrate this progressive variation in pip separation as the IF bandwidth is reduced.

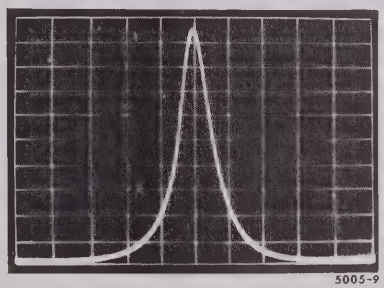
3-32. AMPLITUDE SCALE SWITCH. The AMPLITUDE SCALE switch (28, figure 3-1) determines the type of CRT amplitude presentation. With the switch in the LIN (linear) position, the right hand (VOLTAGE) CRT screen calibrations are used. The horizontal graticule lines are numbered from 0 — 1.0, indicating a direct linear relationship between signal voltage and amplitude. Thus, a signal at half scale (0.5 horizontal line) is one-half the voltage (6 db down) of a signal at full scale (1.0 horizontal line).

3-33. When the AMPLITUDE SCALE switch is in the LOG (logarithmic) position, the left hand (LOG DB) CRT screen calibrations are used. This scale consists of nine dots along the left hand side of the screen in 5 db increments. The top (1.0) horizontal line corresponds to 0 db; the center (0.5) line corresponds to -20 db, and the next to the bottom line (0.1) to -40 db. Accordingly, a signal at half scale (0.5 horizontal line) is 20 db down (1/10 in voltage, 1/100 in power) from a full scale signal.

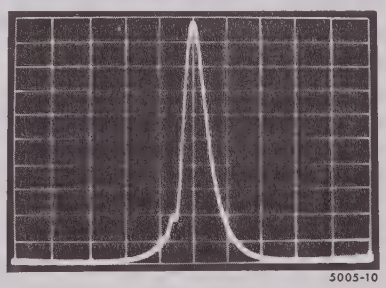
3-34. With the AMPLITUDE SCALE switch in the PWR (power) position, the right hand (VOLTAGE) CRT screen calibrations are again used, but are read directly in power. Thus a signal at half scale (0.5) is half power (3 db down, 70% in voltage) from a full scale signal.



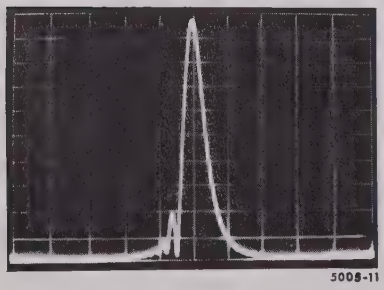
a.



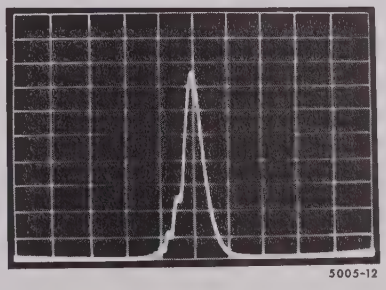
b.



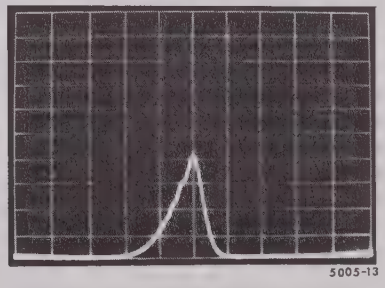
c.



d.

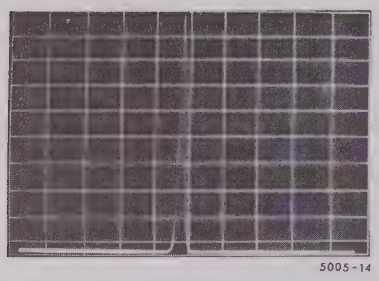


e.

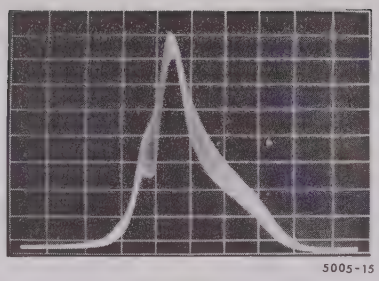


f.

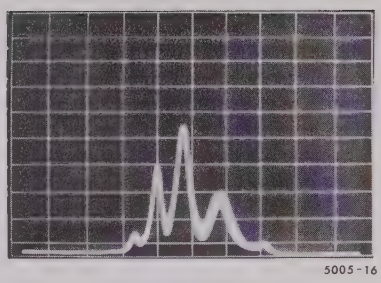
Figure 3-4. Effects of Progressive IF Bandwidth Reduction



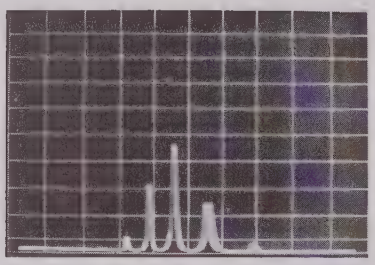
a.



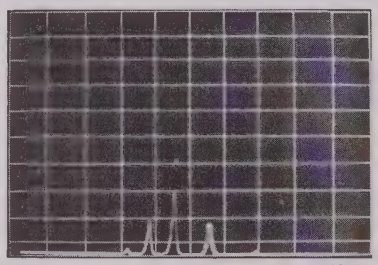
b.



c.

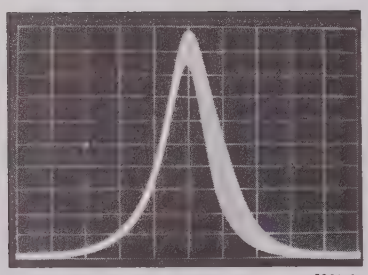


d.

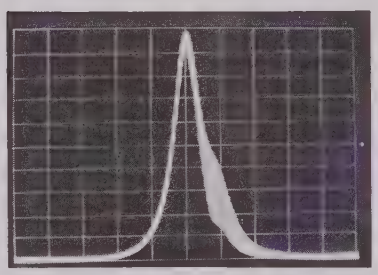


e.

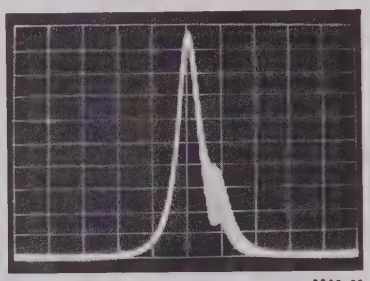
Figure 3-5. Progressive Separation of Closely Spaced Signals



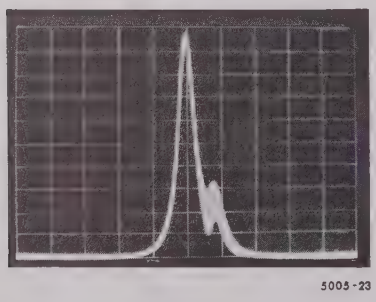
a.



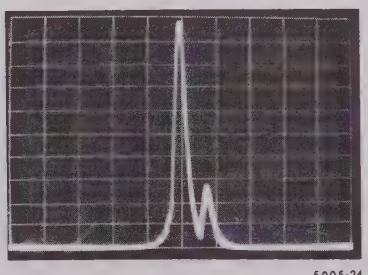
b.



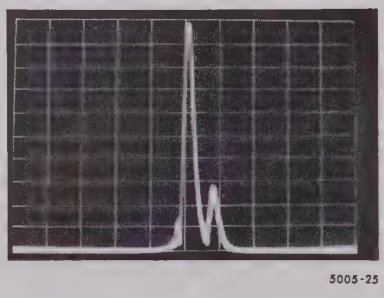
c.



d.



e.



f.

Figure 3-6. Progressive Resolution of Two Signals of Unequal Amplitude

3-35. VIDEO FILTER CONTROL. The VIDEO FILTER control (30, figure 3-1) is used to smooth or suppress unwanted CRT effects such as noise and spurious beating between adjacent signals. Figure 3-7 a shows a typical waveform with the VIDEO FILTER control fully counterclockwise (off); b shows the same signal with the VIDEO FILTER control at the mid-position, while c shows the same signal with the control fully clockwise. For maximum noise suppression with minimum signal distortion, the VIDEO FILTER control should be used only when the sweep rate is below 20 cps.

3-36. INTENSIFIER CONTROL. The INTENSIFIER control (31, figure 3-1) varies the brightness of pulsed signals and noise appearing on the CRT screen. Too low a setting will wash out portions of pulsed signals. Waveforms of figure 3-8 a through c illustrate the effects of a under-intensity, b correct intensity, and c over-intensity.

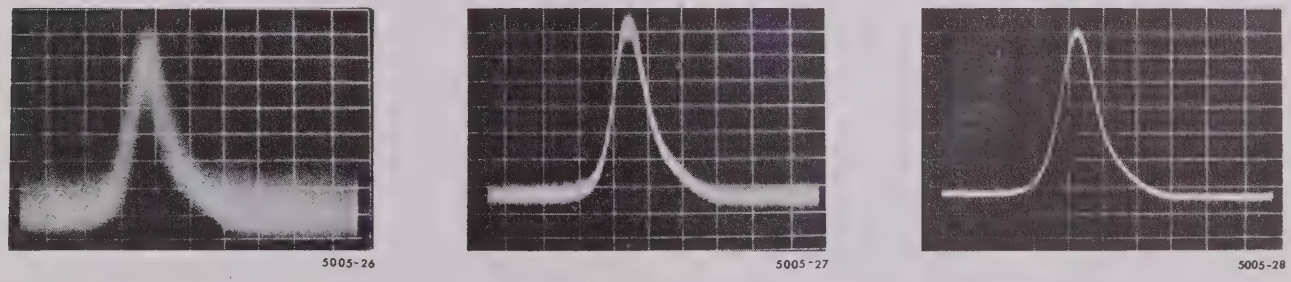
3-37. V POS ADJUSTING SCREW. The V POS adjusting screw (32, figure 3-1) can move the sweep baseline up or down approximately $1\frac{1}{2}$ inches. The relative height of the signals displayed is not affected.

3-38. H POS ADJUSTING SCREW. The H POS adjusting screw (33, figure 3-1) can move the sweep baseline left or right approximately 2 scale divisions. The relative position of signal pips is not affected.

CAUTION

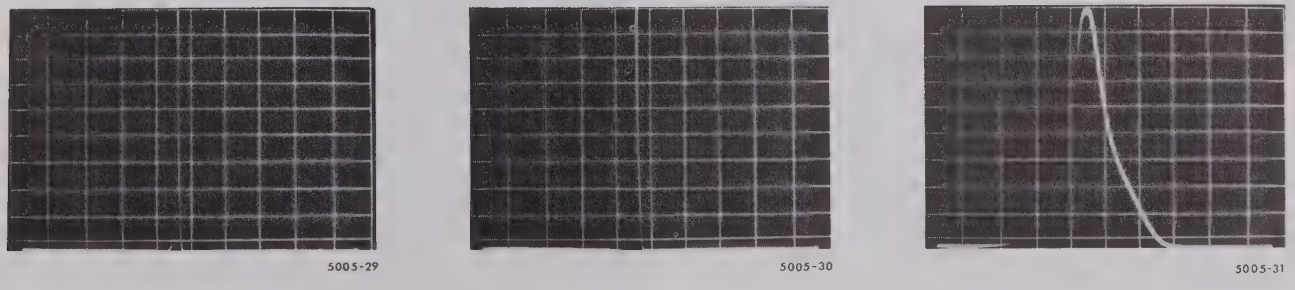
The V POS and H POS adjusting screws should be left at the original factory settings unless adjustments are found necessary during alignment procedures. Adjustment of these controls during normal operation may result in displacement of the CRT presentation with respect to screen calibrations.

3-39. LINE SIZE ADJUSTING SCREW. The LINE SIZE adjusting screw (35, figure 3-1) controls the length of the horizontal baseline. If the trace is too long, resolution is adversely affected; if the trace is too short, the scanning width is reduced. The factory adjustment of this control normally provides a baseline extending 1/4-inch beyond the extreme left and right screen calibrations.



a. b. c.

Figure 3-7. Effects of VIDEO FILTER Control Rotation



a. b. c.

Figure 3-8. Effects of INTENSIFIER Control Rotation

3-40. PRELIMINARY OPERATING PROCEDURES.

3-41. Prior to operating the equipment, perform a quick visual check to ensure that all components are intact and that all internal cables are securely connected. Attach the applicable signal input cable to the corresponding front panel receptacle. Check that the POWER SCALE ILLUM control is fully counterclockwise and connect the power cord to a suitable source of external power. (For external power requirements, refer to paragraph 1-47).

CAUTION

If, at any time during equipment operation, the analyzer should exhibit unusual or erratic behavior, discontinue operation and refer to SECTION 5 — MAINTENANCE for applicable trouble-shooting techniques.

3-42. Turn on equipment power by rotating the POWER SCALE ILLUM control clockwise and set the operating controls to the positions listed in the following tabulation. Note that the CRT baseline appears within 30 seconds after power is applied. Allow a 30 minute warm-up period to permit components to stabilize before proceeding with equipment operation.

NOTE

Before the first operation of new or repaired equipment, perform the Minimum Performance Standards. Checks and Adjustments described in paragraphs 5-8 through 5-28.

CONTROL	POSITION
SPECTRUM CENTERING	Center travel
SWEEP WIDTH	Fully clockwise
IF BANDWIDTH	Fully clockwise
BRILLIANCE	Desired trace brightness
INTENSIFIER	Fully counterclockwise
FOCUS	Sharp trace
ASTIG	Uniform focus
AMPLITUDE SCALE	LIN
IF ATTENUATOR Toggle Switches	Down (out)
IF ATTEN 20 DB	1/16 inch noise
CAL SYNC SEL	LINE
SWEEP RATE	30 cps
SYNC AMPL	Locked sweep (Approximately 1/4 clockwise)
VIDEO FILTER	Fully counterclockwise
MARKER FREQUENCY	0
MARKER LEVEL	One inch marker pip
RANGE	Desired range
INPUT	Use appropriate receptacle
INTERNAL CHECK	Any position
TUNING	Frequency of interest

3-43. GENERAL OPERATING PROCEDURES.

3-44. General procedures applicable to many phases of equipment operation are described in paragraphs 3-45 through 3-86.

3-45. LOCATING SIGNALS OF KNOWN FREQUENCY. If the specific frequency range of interest is known, set the operating controls to the positions indicated in paragraph 3-42. Adjust the TUNING control so that the tuning dial pointer indicates the desired frequency. Slowly search the portion of the spectrum in the vicinity of this frequency until the signal of interest appears on the CRT screen. The exact frequency of the signal can be read only when the signal is directly over the -0+ calibration on the CRT screen scale.

3-46. DETERMINING FREQUENCY OF UNKNOWN SIGNAL. This procedure is essentially the reverse of the procedure described in paragraph 3-45. Using the TUNING control, center the unknown signal directly over the -0+ calibration on the CRT scale. The frequency of the unknown signal can then be read directly from the tuning dial.

3-47. RECOGNIZING UNDESIRABLE SIGNAL RESPONSES. Because of the broadband design of the analyzer input section, spurious responses may appear on the CRT screen. These responses are described in paragraphs 3-48 through 3-55.

3-48. INCIDENTAL FM RESPONSE. Incidental FM appears as a band of frequencies on the CRT screen and is caused by a line frequency ripple in the klystron reflector supply. Incidental FM occurring at a slow sweep speed is shown in a of figure 3-9. Incidental FM at a faster sweep speed is shown in b. The following procedure is a quick method of checking for incidental FM in the circuits following the marker oscillator. This method offers a useful calibration technique but should not be considered extremely accurate.

a. Adjust the SWEEP WIDTH control for minimum sweep width (200 KC). Note that each vertical graticule division now represents 20 KC.

b. Adjust the IF ATTEN 20 DB control for a 1/16 inch noise presentation on the Indicator CRT.

c. Adjust the MARKER FREQUENCY and LEVEL controls for a full scale pip at the center of the CRT screen.

d. Set the CAL SYNC SEL switch to the CAL position.

e. Rotate the SYNC AMPL control fully counterclockwise.

f. Rotate the SWEEP RATE control clockwise. This should provide a sine wave display moving to the right on the CRT screen.

g. Set the CAL SYNC SEL switch to the EXT position.

h. Turn the IF BANDWIDTH control counterclockwise until optimum resolution is obtained.

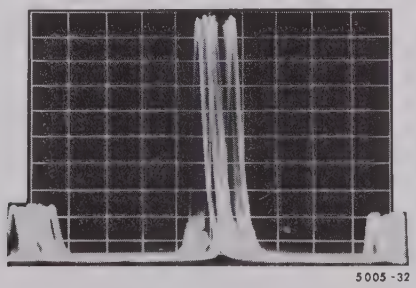
i. The width of the jitter of the top of the pip represents the amount of incidental FM present. This jitter should not exceed 2KC (1/10 CM) for the triode oscillator band and 5 KC (1/4 CM) for the klystron 2.2-6 KMC band.

3-49. 160 MEGACYCLE IF FEED-THRU RESPONSE. This signal is easily recognized since the resultant pip will not move across the CRT screen as the TUNING control is adjusted. Instead, it remains stationary, behaving like an injected marker signal. Harmonic or image responses may be generated by this type of signal, but these will be at a lower amplitude than the signal.

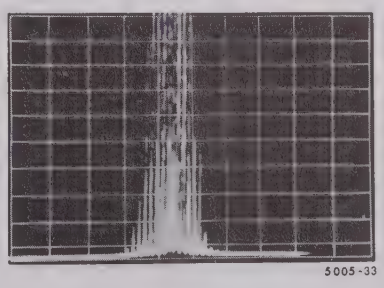
3-50. HIGH AMPLITUDE INPUT SIGNAL RESPONSE. Application of signals with amplitudes greater than -40 dbm may result in the generation of spurious signals. This -40 dbm limitation applies both to signals displayed on the screen and to signals (harmonics) outside the tuned spectrum. For example, injecting a -10 dbm signal at 100 megacycles may cause harmonics of 100 megacycles to produce a spurious signal pip on the CRT screen at 2000 megacycles.

3-51. SPURIOUS IF AMPLIFIER SIGNAL RESPONSE. Spurious in-band signals may be generated in the IF amplifiers if the IF ATTEN 20 DB control is positioned to allow the signal pip amplitude to exceed a full scale reading.

3-52. NARROW HIGH AMPLITUDE MIXER PULSE RESPONSE. Very narrow pulse signals (about .01 microseconds) of high amplitude will produce a video pulse in the input mixer. The detected video pulse contains spectral energy which is accepted directly by the 160 megacycle IF section. Figure 3-10 illustrates the spectrum of a .01 microsecond pulse. Note that 70 per cent of the second lobe falls within the IF "acceptance slot" of the Indicator and would appear as a stationary display across the full width of the CRT screen.



a. Slow Sweep Speed



b. Fast Sweep Speed

Figure 3-9. Incidental FM

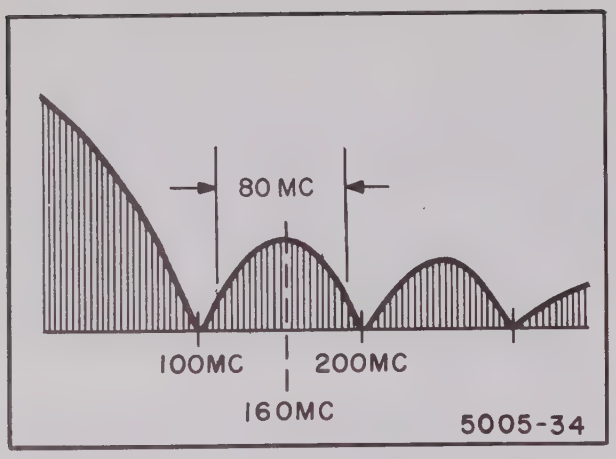


Figure 3-10. Spectrum of .01 Microsecond Pulse

3-53. LOCAL OSCILLATOR IMAGE AND HARMONIC RESPONSE. The origin and frequency of an unidentified pip can be determined as follows:

a. Adjust the operating controls for an 80 megacycle CRT presentation as listed in the following tabulation:

CONTROL	POSITION
MARKER LEVEL	Adjust for $\frac{1}{2}$ to full scale pip.
MARKER FREQUENCY	Adjust for MEGACYCLES dial reading of +40.
SWEEP WIDTH	Adjust to position the marker pip at the +0.5 vertical screen calibration.
MARKER FREQUENCY	Adjust for a MARKER dial reading of -40. The marker pip should be approximately at the -0.5 vertical screen calibration.

b. Adjust the TUNING control to place the signal pip at the +0.5 vertical screen calibration. Note the frequency indicated by the tuning dial pointer. (Use the lower illuminated scale.)

c. Adjust the TUNING control to place the signal pip at the -0.5 vertical screen calibration. Note the frequency indicated by the tuning dial pointer. Calculate and record the difference between the frequencies obtained in steps b and c.

NOTE

In order to minimize the possibility of error due to mechanical backlash, obtain all the Tuning Dial pointer final positions by rotating the TUNING control in a counterclockwise direction.

d. Calculate and record the order of the local oscillator harmonic producing the signal pip using equation (1) below:

$$(1)\quad n = \frac{\text{sweep width}}{f_{diff}} \qquad n = 1,2,3\ldots$$

Where n = order of harmonic of local oscillator producing pip.

f_{diff} = difference in frequency between tuning dial settings.

e. Check whether the pip is a "non-image" or "image" type pip by comparing the direction of pip travel with respect to the direction of travel of the Tuning Dial pointer. If the pip moves in the same direction as the pointer, the pip is an image. If the pip moves in the direction opposite to dial pointer travel, the pip is a "non-image" type.

f. If the pip is a "non-image" type, calculate the frequency of the origin of the signal equation (2) below:

$$(2)\quad f_x = nf_{dial} + (n\text{-}1)\ 160$$

Where: f_x = frequency of the origin of the unknown signal in megacycles

f_{dial} = tuning dial reading when signal being investigated is at the center of CRT screen (f_{dial} read on lower scale of double scales)

n = order of harmonic of local oscillator producing pip.

g. If the pip is an "image" type, calculate the frequency of the origin of the signal using equation (3) below:

$$(3)\quad f_x = nf_{dial} + (n+1)\ 160$$

h. Turn the TUNING control to the calculated signal frequency. The signal pip should appear on the CRT screen. Recheck that the pip is a "non-image" type (pip travels direction opposite to pointer travel as TUNING control is turned and that n= 1 in accordance with equation (1). In rechecking use the scale (upper or lower) containing the frequency calculated for f_x to check that n = 1.

NOTE

Errors can occur in the foregoing method because of the rounding off of "n" to the nearest integer when "n" is a large number (4 or above). If a signal pip does not appear at the calculated place, or if a pip with an incorrect value of "n" appears, repeat and recheck the foregoing procedures. Also try values of "n" one below or one above the value originally calculated.

i. As a final check, an absorption type wavemeter can be inserted between the signal source and the input as shown in figure 3-11. The wavemeter will produce a slight dip in pip amplitude when tuned to the correct frequency. This procedure should not be used until steps a. through h. have been completed. Any attempt to use a wavemeter to measure signals outside its frequency range could produce spurious responses resulting in false conclusions regarding the frequency of the signals being investigated.

NOTE

To determine the frequency of an unknown signal, establish an 80 MC sweep width by adjusting the SWEEP WIDTH control so that the marker pip will align with the extreme graticule calibrations when the MARKER FREQUENCY control is rotated from the +40 MC to the -40 MC positions. Adjust the TUNING control to drive the unknown signal across the screen and note the upper and lower frequency limits indicated by the tuning dial. If the difference between the observed frequencies is approximately 80 MC, the signal is a fundamental and its frequency will be indicated by the tuning dial when the signal is centered on the screen. If the frequency difference is some multiple of 80 MC, the signal is the corresponding harmonic.

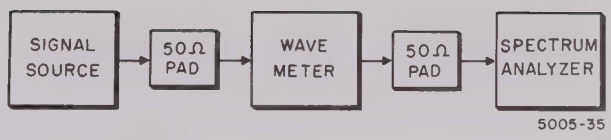


Figure 3-11. Wavemeter Measurement Test Set-up

3-54. FIRST MIXER SIGNAL HARMONIC RESPONSE. Once it has been determined that the pip on the screen is not caused by the fundamental (or correct harmonic) of the local oscillator, the possibility that the pip is some harmonic of a lower frequency signal can be checked. This harmonic can be caused by the input signal overloading the input mixer, or it can be a true component of the input signal. In either case, the fundamental signal can be found by tuning to the various sub-harmonics (1/2, 1/3, 1/4, etc.) of the dial frequency and searching for signals.

3-55. If it is necessary to determine the source of the harmonic, any of the following procedures can be tried:

a. Insert a known large amount of attenuation between the signal source and the analyzer. Use an attenuator which operates in the frequency of both the fundamental and the harmonic. If the harmonic decreases as much as the fundamental, then the harmonic is a signal component. If the harmonic decreases at a much greater rate than the fundamental, the harmonic is produced in the input mixer of the analyzer.

b. Insert a high pass filter between the signal source and the analyzer. This would eliminate the fundamental but have a negligible effect on the harmonic. Therefore, if the harmonic is not eliminated, it is a signal component; if the harmonic is eliminated, it is created in the input mixer.

c. Insert a wavemeter in the signal path. If the harmonic produces a wavemeter dip at the harmonic frequency, then the harmonic is a signal component. Check that the wavemeter does not cause a dip at the fundamental frequency when the wavemeter is turned to the harmonic.

3-56. DETERMINING FREQUENCY OF SPURIOUS SIGNAL. Assume that a spurious signal has been discovered at the 350 megacycle point on the Tuning Dial. By following the procedures described in paragraphs 3-53 through 3-55 the true frequency of this signal

can be determined as shown in the following example:

a. In accordance with paragraph 3-53, the SWEEP WIDTH control is adjusted for an 80 megacycle sweep width using the marker pip.

b. In rotating the TUNING control it is noted that the signal pip moves opposite to tuning dial pointer travel and is, therefore, a "non-image" signal.

c. Using the TUNING control, the signal pip is positioned at the +0.5 vertical screen calibration. The tuning dial pointer indicates 359.5 megacycles.

d. The TUNING control is readjusted to position the signal pip at the -0.5 vertical screen calibration. The tuning dial pointer now indicates 340.5 megacycles.

e. Harmonic order (n) is determined in accordance with paragraph 3-53 using the following equation:

$$n = \frac{80}{359.5-340.5} = \frac{80}{19} = 4.2 \cong 4$$

f. The input signal frequency (f_x) is calculated in accordance with paragraph 3-53 using the following "image equation".

$$f_x = 4\ (350) + 5\ (160) = 2200 \text{ megacycles.}$$

g. Accordingly the TUNING control is readjusted for a tuning dial pointer reading of 2200 megacycles and a new pip appears on the CRT screen.

h. When the TUNING control is turned slightly, this new pip moves in a direction opposite to the tuning dial pointer travel indicating that the new pip is not produced by an image.

i. When the pip is positioned to the -0.5 CRT screen calibration the tuning scale pointer reads 2240 megacycles.

j. When the pip is positioned to the +0.5 CRT screen calibration, the tuning scale pointer reads 2165 megacycles.

k. Computation shows that 2240 megacycles minus 2165 megacycles equals 75 megacycles. This answer is sufficiently close to 80 megacycles to show that 2200 megacycles is the actual frequency of the signal. The following equation is used in obtaining dial frequencies at other places which would be caused by the 2200 MC signal.

$$f \text{ dial} = \frac{f_x - (n \pm 1)\ 160}{n} = \frac{2200 - (n \pm 1)\ 160}{n}$$

3-57. The following list of "image" and "non-image" frequencies has been calculated with a constant "non-image" fundamental (2200 megacycles) and with various values of "n".

n VALUE	"NON-IMAGE" HARMONIC PIPS (FREQ. in MC)	"IMAGE" HARMONIC PIPS (FREQ. in MC)
1	2200	1880
2	1020	860
3	627	520
4	430	350
5	312	248
6	233	180
7	177	131
8	154	95
9	102	66
10	76	44
11	54.5	22.5
12	36.6	10
13	21.5	

3-58. These signals will appear on the Indicator when a 2200 megacycle input is present. Unless the 2200 megacycle signal is suppressed, all the frequencies listed (except 2200 megacycles) should be disregarded in a search for additional signals.

NOTE

All the pips produced by the mixing of an input signal with harmonics of the local oscillator fall at points on the tuning scale below the true input frequency. For this reason when searching for unknown signals, it is good practice to start at the highest frequency of interest and search downward in frequency.

3-59. MEASURING FREQUENCY TO AN ACCURACY OF ONE PERCENT. Once the approximate frequency of a signal is known and it is desired to measure the frequency to the 1% accuracy of the equipment the following procedure should be used:

a. Adjust the SWEEP WIDTH control to obtain a sweep width of 10±5 megacycles.

b. Apply a crystal-checked 160 MC signal at the INPUT 10 MC - 12KMC receptacle and adjust the SPECTRUM CENTERING control to center the pip on the screen.

c. Adjust the MARKER FREQUENCY control to correspond with the 160 MC pip at the center of the screen. This should be 0 on the MARKER dial.

d. Adjust the MARKER LEVEL control to produce a full scale marker pip.

e. Disconnect the 160 MC signal and apply the desired signal.

f. Adjust the TUNING control until the signal pip coincides with the center of the marker pip.

g. Read the exact frequency on the tuning dial.

3-60. MEASURING SIGNAL AMPLITUDE. Paragraphs 3-61 through 3-69 provide methods for measuring signal amplitude. These procedures are arranged in sequence from the most simple to the most precise.

3-61. RELATIVE AMPLITUDE COMPARISON. The following steps represent the most simple method for comparing the relative amplitude of two discrete signals having dispersions of 80 megacycles or less:

NOTE

Due to the variation in flatness response of the Tuning Head over any one frequency range, or from one range to another, only absolute amplitude measurements of signals exceeding 80 megacycles dispersion can be made. Accurate relative amplitude comparison can only be made when both signals are present on the CRT screen at the same time.

a. Connect the signals to be measured to the appropriate input receptacle on the front panel. Use an RF pad between the input frequency source and the input receptacle.

NOTE

When the amplitude of the input frequency is extremely small, further signal attenuation from an RF impedance matching pad may prove impractical. RF padding, however, should be used whenever possible.

b. Adjust the SWEEP WIDTH control to a point where a minimum sweep width adjustment displays the signal of interest on the CRT.

c. Set the AMPLITUDE SCALE selector switch to the desired position.

d. If required, adjust the IF BANDWIDTH control for best resolution. (For adjustment of this control, refer to paragraph 3-28.)

e. Adjust the IF ATTEN 20 DB control so that the largest signal pip present on the CRT screen is exactly full scale.

f. Read the relative amplitudes of the signal pips. (The accuracy of the relative amplitudes is approximately 3 db). Flatness accuracy increases as the sweep width is reduced.

3-62. For more accurate measurements, it is necessary to make a flatness curve for the frequency range of interest. The flatness curve, which indicates the amplitude relationship of frequencies shown on the CRT, can be used for calibration purposes. Two methods of producing a flatness curve are listed in paragraphs 3-65 and 3-66.

3-63. RESPONSE FLATNESS MEASUREMENT. For this equipment, "flatness" is defined as the total variation in db of amplitude response of a single pip as a signal of constant amplitude is varied over a given frequency range. The overall flatness of this equipment is the algebraic sum of the flatness of the first IF bandpass plus the flatness at the Tuning Head input circuits. A typical IF flatness curve is shown in figure 3-12.

NOTE

When measuring IF flatness, insert a 3 db or 6 db pad in series with the signal source connected to the front panel DIRECT INPUT receptacle to provide a termination for the RF cable used. The IF flatness will change somewhat with line voltage due to variations in filament current.

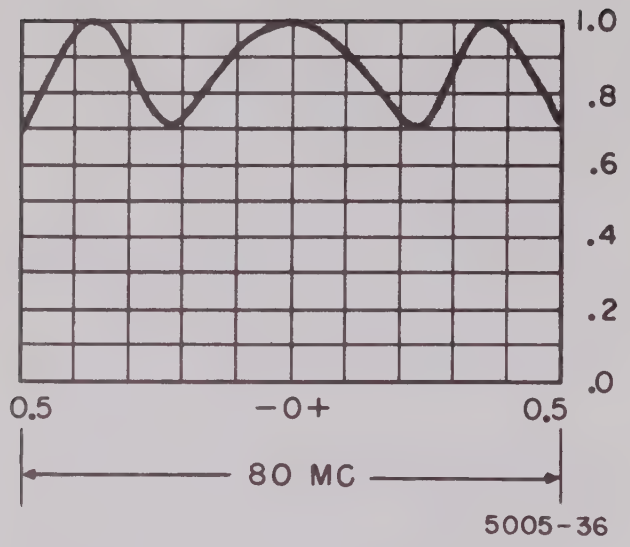


Figure 3-12. Typical IF Flatness Curve

3-64. Because input circuitry frequency response is relatively flat over any selected 80-megacycle spectrum segment, overall equipment response does not differ materially from the IF response. Although the design specification for IF response is a maximum of 3 db, the usual result is $\pm 1\frac{1}{2}$ db over most of the RF range. At a few discrete frequencies, however, it is possible that, due to crystal resonance or mismatches, there will be a dip in input section response. This dip, when combined with the IF response, yields an overall flatness greater than 3 db.

3-65. ROUGH FLATNESS CURVE CONSTRUCTION. A rough flatness curve can be made by marking the spot on the face of the CRT at which each individual frequency peak occurs. Adjust the TUNING control so as to cause the largest signal present to move back and forth across the full width of the CRT screen. The top of the CRT signal at each position of the TUNING control represents the flatness curve. Adjust the IF ATTEN 20 DB control so that the highest point traced by the top of the pip is at full scale. Using a grease pencil, mark the curve traced by the top of the pip while adjusting the TUNING control to drive the signal across the CRT screen.

3-66. PRECISE FLATNESS CURVE CONSTRUCTION. A more accurate flatness curve can be marked on the CRT screen by using an external signal generator. Connect a signal at the frequency of interest to the appropriate front panel input receptacle. Keeping the signal generator output level constant, vary the frequency of the signal generator over the required range. If a long cable is normally used to connect signal being investigated to the equipment, the same length of cable must be used to connect the signal generator being used for calibration.

3-67. The IF flatness response of each signal should not have more than 3 db deviation in amplitude across any 80 megacycle spectrum of the CRT as the tuning dial pointer is moved across the scale. A gradual change in signal amplitude is considered to be a change in sensitivity, while an abrupt up-and-down change is considered to be a "hole".

3-68. If a "hole" greater than 6 db is encountered, the response may be improved through the use of more accurate impedance matching devices between the signal generator output and the equipment input receptacle. Another method of improving circuit response is to adjust the crystal bias.

CAUTION

Adjustment of crystal bias should be performed only if the frequency of concern is used extensively. It is possible that adjusting crystal bias for a specific frequency may have an adverse effect on the response of other frequencies throughout the spectrum. Before adjusting, record the crystal bias voltage indication of the Internal Check meter. At the completion of monitoring this particular frequency, return the crystal bias to its original level.

3-69. ABSOLUTE AMPLITUDE MEASUREMENT. The following steps describe the method for measuring the absolute amplitude of an input signal:

a. Connect the input signals to the appropriate front panel receptacle. Adjust the IF ATTENUATOR control so that the largest signal pip present on the CRT screen is exactly full scale.

b. Remove the input signal. Without altering the settings of the analyzer controls, inject a signal of the same frequency from an external signal generator. Adjust the attenuator of the signal generator to provide a full scale pip at the center of the CRT screen.

c. Read the absolute amplitude of the signal of interest on the attenuator of the signal generator.

d. Repeat steps a. through c. for each signal of interest.

3-70. DETECTING LOW LEVEL SIGNALS. The detection of low level signals requires a compromise between obtaining maximum sensitivity and a rapid search technique. Maximum equipment sensitivity occurs at a very narrow sweep width of approximately one kilocycle. Under this condition, however, the operator would require great skill in continuously observing the CRT while slowly adjusting the TUNING control.

3-71. Since a normal test signal is easiest to locate when both the sweep width and IF bandwidth are adjusted to 80 megacycles, the range between maximum and minimum sensitivity is about 20 db. Accordingly, for initial location of a low level signal, a compromise within this 20 db range has been found to be most practical. Recommended control settings are listed in paragraphs 3-72 and 3-73.

3-72. AM, FM, AND CW MODULATED SIGNAL DETECTION. For optimum detection of low level AM, FM, or CW modulated signals, set the controls listed below to the positions indicated in the following tabulation. All other controls may be set as desired. Slowly turn the TUNING control through the frequency range of interest. This procedure provides a sensitivity approximately 10 db less than maximum but facilitates the most rapid tuning search.

CONTROL	POSITION
RANGE	Desired frequency range
SWEEP WIDTH	Approximately 5 MC (Determine by marker setting)
CAL SYNC SEL	LINE
SWEEP RATE	15 cps (4 sine waves)
VIDEO FILTER	Position where noise just begins to be eliminated
AMPLITUDE SCALE	LIN
IF BANDWIDTH	Fully counterclockwise
IF ATTEN 20 DB	1/4 inch noise on CRT

3-73. PULSE SIGNAL DETECTION. For optimum detection of low level pulse signals, set the operating controls to the positions indicated in paragraph 3-72. Slowly rotate the TUNING control through the frequency range of interest. This procedure is the best method for detecting pulse signals with 0.5 to 10 microsecond pulse-widths and repetition rates from a few hundred to a few thousand pulses per second.

3-74. MEASURING HARMONIC RESPONSE. To measure the harmonic response of a known fundamental frequency, perform the following steps:

a. Connect the input signal to the appropriate front panel input receptacle and adjust the TUNING control to center the signal pip on the CRT screen.

b. Adjust the IF ATTEN 20 DB control for a full scale deflection of the signal.

c. Disconnect the input signal and, without altering equipment control settings, connect an identical input frequency from a signal generator to the same input receptacle.

d. Adjust the signal generator attenuator for a full scale signal deflection. The output of the signal generator should not exceed -40 dbm.

e. Disconnect the signal generator and reconnect the signal under examination to the appropriate input receptacle. Adjust the TUNING control until the harmonic frequency under consideration appears on the CRT screen.

f. Adjust the IF ATTEN 20 DB control for a full scale deflection of the harmonic signal pip.

g. Disconnect the input signal and, without altering equipment control settings, connect an identical from a signal generator to the same input receptacle.

h. Adjust the signal generator attenuator for a full scale signal deflection. The output of the signal generator should not exceed -40 dbm.

i. Refer to the procedure described in paragraph 3-54 for identification of first mixer harmonics and determine whether the harmonic response is a true multiple of the signal or whether it is generated within the equipment. If the fundamental input signal is kept below -40 dbm, however, the equipment should produce no visible harmonic response.

3-75. INTERPRETING VARIOUS CRT SCREEN PRESENTATIONS. Various types of CRT screen presentations are described in paragraphs 3-76 through 3-86. The operator should recognize

these waveforms as representing specific types of input signals.

3-76. AM SIGNAL PRESENTATION. An unresolved amplitude modulated carrier of low frequency appears as a single deflection of variable height on the CRT screen. The higher the AM input frequency, the easier the sidebands can be separated from the marker frequency and, therefore, the better the resolution. Figure 3-13 a shows the marker pip (in the center) and the sidebands of a modulating frequency, while b shows the marker pip and sidebands of a higher modulating frequency.

3-77. As the modulation frequency increases, the sidebands move away from the carrier frequency (marker pip). Sideband separation can also be obtained by turning the SWEEP WIDTH control counterclockwise. The positioning of the sidebands with the SWEEP WIDTH control, however, has no effect on the frequency span between the sidebands.

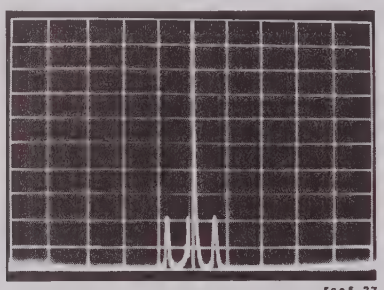
NOTE

If the relative heights of the sidebands vary as the TUNING control is turned, this effect is due to incidental FM.

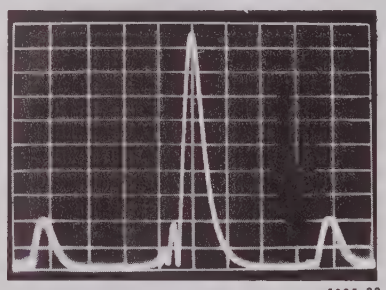
3-78. FM SIGNAL PRESENTATION. In frequency modulation, the carrier frequency varies in accordance with both the frequency and the amplitude of an audio modulating signal. While simple FM waves can be readily studied mathematically, the complex waves normally encountered in military and commercial applications present a more difficult task. This is particularly true since the actual FM waves often differ markedly from their computed structure. Use of the spectrum analyzer permits the actual spectrum to be viewed directly and analyzed for components differing from the predicted structure.

3-79. Frequency modulated signals, when viewed on the CRT screen, appear as a series of vertical deflections. Figure 3-14 a shows FM modulation with the carrier balanced out and the sidebands resolved. (The frequency difference from one pip to the next represents the audio frequency.) Figure 3-14 b shows the same FM signal but with the sidebands unresolved.

3-80. PULSE SIGNAL PRESENTATION. A spectrum analyzer is often used as a sensitive

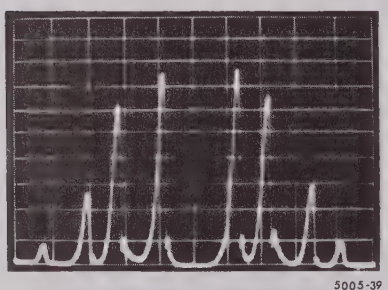


a. Low Modulating Frequency

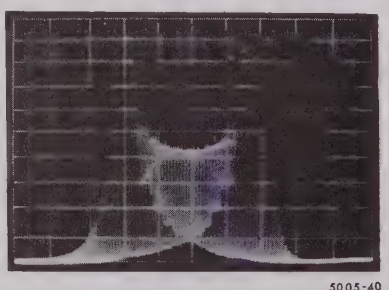


b. Higher Modulating Frequency

Figure 3-13. Amplitude Modulated Signal Showing Sidebands



a. Sidebands Resolved



b. Sidebands Unresolved

Figure 3-14. Frequency Modulated Signal

indicator to check the operation of pulse-modulated transmitters for excessive frequency modulation of the pulse signal. Excessive frequency modulation tends to remove power from the central lobe of the pulse and broadening the pulse thus placing excessive power into the side lobes. Figure 3-15 a illustrates the spikes indicative of a pulsed RF signal. Figure 3-15 b shows the same signal at a slower speed.

3-81. The response of a spectrum analyzer to pulsed RF signals has been analyzed in detail by many groups; an especially informative discussion on this subject is contained in the Radiation Laboratory Series, Volume 11. Technique of Microwave Measurements, Chapter 7, entitled The Measurement of Frequency Spectrum and Pulse Shape written by Carol G. Montgomery.

3-82. This analysis deals with very short pulses ranging from 0.1 microsecond to several microseconds and with a relatively long time interval between pulses. In general, the IF amplifier of the spectrum analyzer is narrow compared to the reciprocal of the pulse width but is still sufficiently broad so that the transient generated by a pulse has decayed entirely before the next pulse occurs.

3-83. The analysis shows that there is a loss in response of an analyzer between CW signals and pulsed signals due to the fact that the required CW IF bandwidth is narrow compared to the bandwidth necessary to transmit a pulse without distortion. The response of the analyzer to a pulsed signal is provided by the following equation:

$$e = \frac{A\ 3\ \tau\ (\Delta f)}{2}, \text{ where } \tau\ (\Delta f) \leq 0.1$$

Where A = response to a CW signal in volts

τ = RF pulse length (rectangular pulse)

Δ = 3 db down IF bandwidth

e = voltage response to a pulse

3-84. For example, it was found that there was no response by the analyzer to a 0.1 microsecond pulse at 38 KMC. The sensitivity of the analyzer to a CW signal with the minimum IF bandwidth (1 KC) was -55 dbm. In the case of a 0.1 microsecond pulse and a bandwidth of 80 KC is illustrated in the following equation:

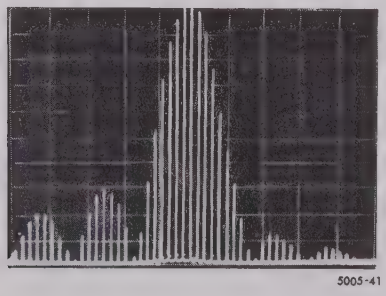
$$e = A\ \frac{3}{2}\ (.1 \times 10^{-6})\ (80 \times 10^{3}) = 0.012A$$

3-85. This result corresponds to a loss of approximately 38 db. In addition, the noise is increased from that obtained when measuring the CW tangential sensitivity at a 1 KC bandwidth, due to the fact that the analyzer is now operating at an 80 KC IF bandwidth. The increase in noise voltage is proportional to the square root of the bandwidth, or about 19 db additional noise. The tangential sensitivity of the analyzer to a 0.1 microsecond pulse is, therefore, -55 + (19 + 38) or +2 dbm.

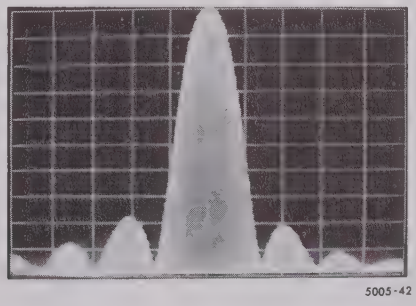
3-86. Any signal greater than approximately -10 dbm would overload and block the input crystal causing the analyzer to become inoperative. This -10 dbm signal would, therefore, be 12 db below the noise. Since good spectrum contains a signal to noise ratio of about 20 db, a -10 dbm input level with a 0.1 microsecond pulse frequency requires an increase in sensitivity of about 32 dbm.

3-87. SPECIALIZED OPERATING PROCEDURES. Specific equipment operating procedures representing several common applications of the spectrum analyzer are listed in paragraph 3-88 through 3 — 104.

3-88. OPERATION AS A SENSITIVE RECEIVER. Because of its high sensitivity, this equipment can be used as a sensitive receiver to perform numerous functions such as the



a. Fast Sweep Rate



b. Slow Sweep Rate

Figure 3-15. Pulsed Signal at Fast and Slow Sweep Rates

Insertion Loss Measurements, Frequency Response Checks, VSWR Measurements, and Wavemeter Calibration procedures described in paragraphs 3-89 through 3-92.

3-89. INSERTION LOSS MEASUREMENTS. To measure the insertion loss of a network at any particular frequency set up the test equipment as shown in figure 3-16 a and perform the following steps:

a. Set the equipment operating controls to the positions indicated in paragraph 3-42, except set the MARKER LEVEL control to OFF.

b. Using the TUNING control, set the Tuning Dial pointer to the desired frequency, adjusting the control until the signal pip appears on the CRT screen.

NOTE

If the network under test has a high insertion loss (40 to 100 db), adjustment of the SWEEP WIDTH, IF BANDWIDTH, and IF ATTEN 20 DB controls may be necessary to ensure maximum equipment sensitivity.

c. Adjust the signal generator for a full scale signal pip on the CRT screen. Note and record the signal generator dbm output level.

d. Remove the network under test as shown in figure 3-16 b and repeat step c.

e. The insertion loss for the test frequency is the difference (in dbm) between the signal generator output levels noted in steps c and d.

3-90. FREQUENCY RESPONSE MEASUREMENTS. To measure the frequency response of a network set up the test equipment as shown in figure 3-16 a and perform the following steps:

a. Set the equipment operating controls to the positions indicated in paragraph 3-42 except set the MARKER LEVEL control to the OFF position.

b. Using the TUNING control, set the tuning dial pointer to the desired frequency, adjusting the control until the signal pip appears on the CRT screen.

c. Set the AMPLITUDE SCALE switch to the LOG position.

d. Adjust the signal generator output level as required to place the top of the signal pip one scale division below the 0 DB line.

e. Keeping the signal generator output level constant, vary the output frequency through the frequency range of interest. Note the frequency which provides maximum signal amplitude.

f. With the signal generator set to the frequency providing maximum signal amplitude, adjust the output level to place the top of the signal pip exactly at the 0 DB scale division.

g. With the signal generator output level held constant, vary the output frequency through the frequency range of interest. The top of the signal pip will trace the response curve (in db) of the unit under test.

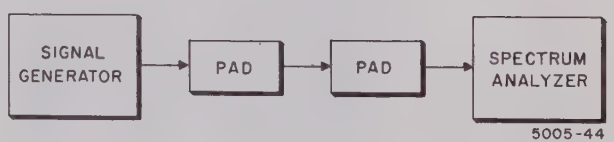
NOTE

This procedure neglects any variation in the frequency response of the analyzer. If maximum accuracy is required, set up the test equipment as shown in Figure 3-16 b and repeat steps a. through g. to provide a basic response curve for the test system. This curve may then be compared with the curve originally obtained in step g. to produce an absolute network response curve.

3-91. VSWR MEASUREMENTS. To measure the voltage standing wave ratio of a unit set up the test equipment as shown in figure 3-17 and perform the following steps:

a. Set the analyzer operating controls to the positions indicated in paragraph 3-42 except set the MARKER LEVEL control to the OFF position.

a.



b.

Figure 3-16. Insertion Loss Test Set-up

b. Connect the probe to the appropriate analyzer input receptacle.

c. Adjust the signal generator for a suitable frequency and output level.

d. Place the probe over the slotted line and adjust the analyzer for a stable display.

e. Move the probe back and forth over the slotted line and note the variations in amplitude of the signal pip. The amount of change between minimum and maximum signal amplitude represents the VSWR. (See figure 3-18.)

3-92. WAVEMETER CALIBRATION. To calibrate a wavemeter, the analyzer can be used as a sensitive detector. Set up the test equipment as shown in figure 3-19 and perform the following steps:

a. Set the analyzer operating controls to the positions indicated in paragraph 3-42 except set the MARKER LEVEL control to the OFF position.

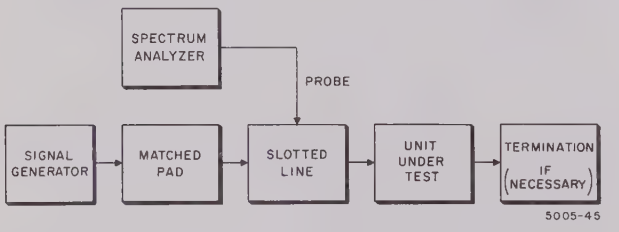


Figure 3-17. VSWR Test Set-up

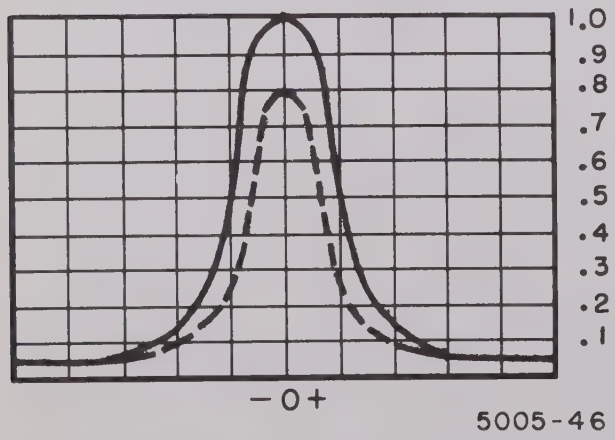


Figure 3-18. Typical VSWR Response Curve

b. Adjust the signal generator for a suitable frequency and output level.

c. Adjust the analyzer for a stable display with a full scale signal pip.

d. Tune the wavemeter transmission cavity for a maximum marker pip deflection on the CRT screen.

3-93. PRECISE FREQUENCY MEASUREMENTS. Precise determination of the frequency of interest can be made by using the analyzer as a sensitive indicator. Set up the test equipment as shown in figure 3-20 and perform the following steps:

a. Set the analyzer operating controls to the positions indicated in paragraph 3-42 except the MARKER LEVEL control to the OFF position.

b. Adjust the TUNING control until the standard frequency signal appears at the center of the CRT screen.

c. Adjust the controls of the unit under test so that its signal appears superimposed on the standard frequency signal indicating that they are now identical.

Figure 3-19. Wavemeter Calibration Test Set-up

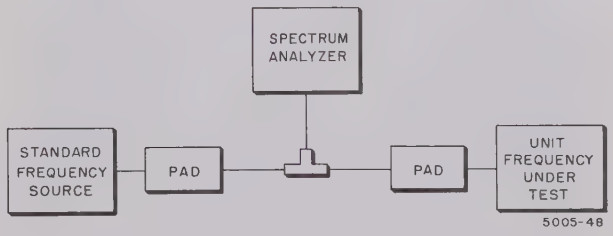


Figure 3-20. Visual Frequency Comparison Test Set-up

3-94. FILTER FREQUENCY RESPONSE MEASUREMENTS. To measure the frequency response of a filter set up the test equipment as shown in figure 3-21 and perform the following steps:

a. Set the analyzer operating controls to the positions indicated in paragraph 3-42 except set the MARKER LEVEL control to the OFF position.

b. Set the signal generator to the desired frequency and adjust the analyzer TUNING control to center the signal pip on the CRT screen.

c. Depending on the anticipated amount of signal displacement, set the AMPLITUDE SCALE switch to the LIN or LOG position.

NOTE

If the expected displacement is relatively small, use the LIN position for greater accuracy; if the expected displacement is large, use the LOG position which provides a greater display range and can be read directly in db.

d. Keeping the signal generator output level constant, vary the frequency through the band of interest and note the frequency providing the greatest signal pip amplitude.

e. With the signal generator set to this frequency, adjust the output level to place the signal pip at the 0 DB line on the CRT screen.

f. Keeping the signal generator output level constant, vary the output frequency through the frequency range of interest. The top of the signal pip will trace the filter response curve on the CRT screen. (For a typical filter frequency response curve, see figure 3-22.)

NOTE

This procedure neglects any variation in the frequency response of the test components. If maximum accuracy is required, remove the filter from the test set-up and repeat steps a. through f. to establish a basic response curve for the test set-up. This curve should then be compared with the filter response curve previously obtained in step f to produce an absolute filter frequency response curve.

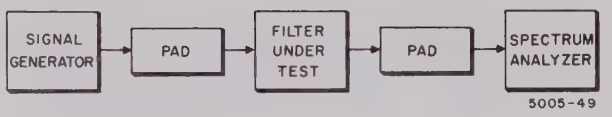


Figure 3-21. Filter Response Test Set-up

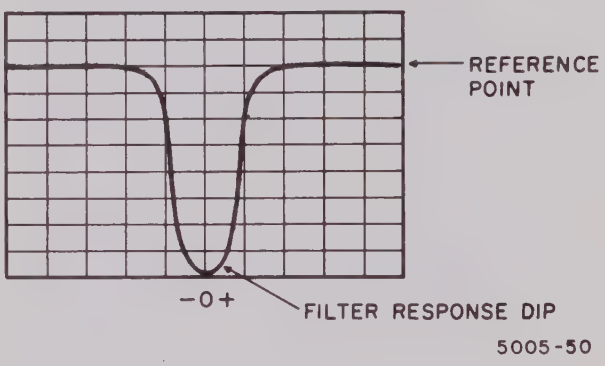


Figure 3-22. Typical Filter Response Curve

3-95. FILTER INSERTION LOSS MEASUREMENTS. To check the insertion loss of a filter, set up the test equipment as shown in figure 3-16 b and perform the following steps:

a. Set the analyzer operating controls to the positions indicated in paragraph 3-42 except set the MARKER LEVEL control to the OFF position.

b. Set the signal generator to the desired frequency and adjust the analyzer TUNING control to center the signal pip on the CRT screen.

c. Adjust the signal generator output level to provide a full scale signal pip.

d. Keeping the signal generator frequency and output level constant insert the filter between the matching pads as shown in figure 3-16 a. Note the change in signal pip amplitude on the CRT screen. This represents the insertion loss at the selected frequency.

e. Repeat steps b through d at different frequencies as required to establish further insertion loss data.

3-96. FREQUENCY STABILITY MEASUREMENTS. To measure the short-term frequency stability of the unit under test, place the unit in its normal operating environment and perform the following steps:

a. Set the analyzer operating controls to the positions indicated in paragraph 3-42 and connect the signal to be checked to the appropriate analyzer front panel input receptacle.

b. Adjust the TUNING control until the signal under test appears on the CRT screen.

c. Adjust the SWEEP WIDTH and MARKER FREQUENCY controls as required to superimpose the marker pip on the signal pip. Note and record the MARKER dial indication.

d. Change the environment of the unit under test to a predetermined degree and note the frequency shift.

e. Adjust the MARKER FREQUENCY control as required to superimpose the marker pip on the signal pip. Note and record the MEGACYCLES dial indication. The difference in megacycles between the two dial indications represents the frequency shift caused by the change in the test environment.

NOTE

Although the analyzer is a versatile and accurate test instrument, its marker oscillator is not crystal controlled and should not be considered extremely stable over long periods of operation. When a long-term frequency stability measurement is desired, a crystal calibrator signal should be used in place of the analyzer marker. The optional crystal calibrator (paragraph 1-53) is excellent for this purpose.

3-97. OPERATION AS A SENSITIVE INDICATOR. In addition to its measurement capabilities, the analyzer also functions as sensitive indicator enabling the operator to monitor numerous signal phenomena. A few of these are described in paragraphs 3-98 through 3-104.

3-98. MICROPHONICS. To display the microphonics content of a given signal, perform the following steps:

a. Set the analyzer operating controls to the positions indicated in paragraph 3-42 except set the MARKER LEVEL control to the OFF position.

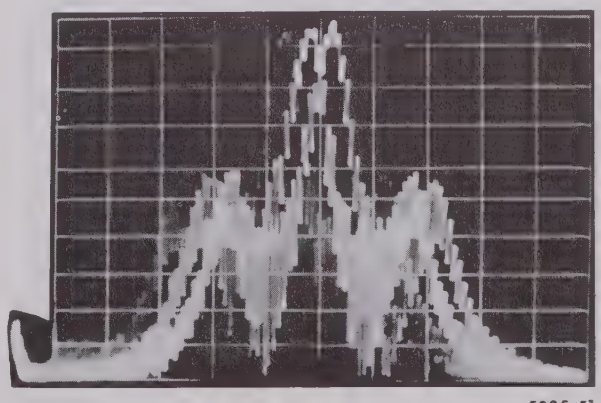
b. Connect the test signal to the appropriate analyzer front panel input receptacle.

c. Adjust the TUNING control until the test signal appears at the center of the CRT screen.

d. Adjust the SWEEP WIDTH control for a suitable display. The microphonic content of a signal can be identified as the noise or distortion present in the signal. (For an example of microphonic content, see figure 3-23.)

3-99. OSCILLATOR SQUEGGING. Squegging of an oscillator is the recurrent interruption of oscillations at an audio or RF rate. Since the spectrum of oscillator squegging resembles the spectrum of a pulse modulated wave, the squegging presentation contains sideband components in addition to the oscillator frequency. Accordingly, the output of a continuous oscillator can be monitored by the analyzer and checked for squegging as well as spectral purity.

3-100. SPURIOUS SIGNALS. The analyzer can be used to locate spurious signals of oscillators, amplifiers, and transmitters. This can be accomplished by first formulating a chart of the known frequencies of the equipment under test. Then, by using a filter to filter out the known input frequency to the spectrum analyzer, the technician can observe various remaining frequencies on the CRT and seek out the spurious signals. Spurious signals will be those signals which appear on the CRT but which are not on the formulated chart of known frequencies of equipment under the test.



5005-51

Figure 3-23. Typical Example of Microphonic Effects

3-101. BALANCED MODULATION. The analyzer can also be used as an aid in adjusting balanced modulators for minimum transmission of the carrier. This adjustment is accomplished merely by tuning the analyzer to the carrier frequency of the unit under test. With the use of the balance control on the balanced modulator, adjust the carrier pip for minimum height on the CRT screen. Balanced modulation will appear as shown in figure 3-24.

3-102. EXTERNAL SIGNAL FM. The FM content of a specific external signal can be determined by subtracting the incidental FM of the analyzer from the total FM of the displayed signal as indicated in the following steps:

a. Using a signal generator known to have a low level of incidental FM, tune it to the test frequency. If this frequency is above the range of the generator, use the highest fundamental which will provide a harmonic signal at the desired frequency.

NOTE

The order number of a harmonic is directly proportional to the amount of incidental FM occurring with the harmonic.

b. Tune the analyzer to the test frequency.

c. Adjust the signal deviation as directed in steps a through h of paragraph 3-48.

d. Center the marker pip on the CRT screen and, using an audio signal generator to provide sidebands, measure the deviation of the analyzer's incidental FM.

e. Substitute the external signal for the RF signal generator input and repeat step c.

f. The incidental FM of the signal under test can then be determined by subtracting the analyzer FM (obtained in step d) from the total FM (obtained in step e).

NOTE

The preceding method provides useful calibration data but should not be considered extremely accurate.

3-103. COMMUNICATION BAND DEFECTS. Because of its high sensitivity, the analyzer can be used to great advantage in monitoring the communication bands for frequency drift, signal level drop, in stability, and unwanted modulation characteristics. By observing the bandwidth of the signal under test, the user can also note if the signal is exceeding or spilling over its allotted tolerance.

3-104. Spurious outputs of transmitters can be located by using the analyzer as a frequency-selective voltmeter or power measuring device. To locate and measure the spurious output of the transmitter under test, set up the test equipment as shown in figure 3-25 and perform the following steps:

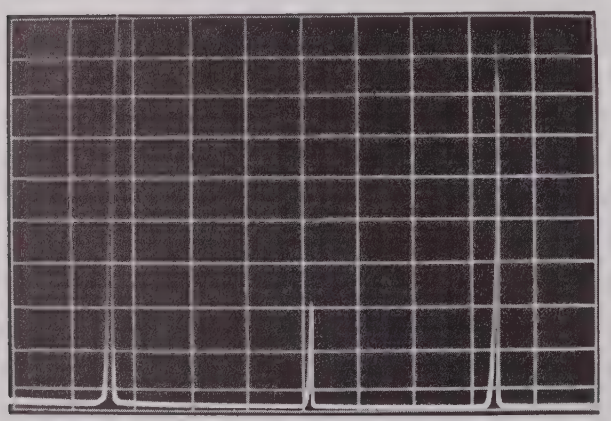
a. Set the analyzer operating controls to the positions indicated in paragraph 3-42 except the MARKER LEVEL control to the OFF position.

b. Tune the transmitter under test to a standard frequency and connect the test signal to the appropriate analyzer input receptacle by-passing the fundamental frequency rejection network.

c. Tune the analyzer to the fundamental frequency of the transmitter under test, centering the signal on the CRT screen.

d. Connect the fundamental frequency rejection network as shown in figure 3-25 and note that the signal on the CRT screen disappears.

e. Adjust the IF ATTEN 20 DB control for maximum gain and set the TUNING control for a CRT presentation of the frequency of interest.



5005-52

Figure 3-24. Spectrum of Balanced Modulation

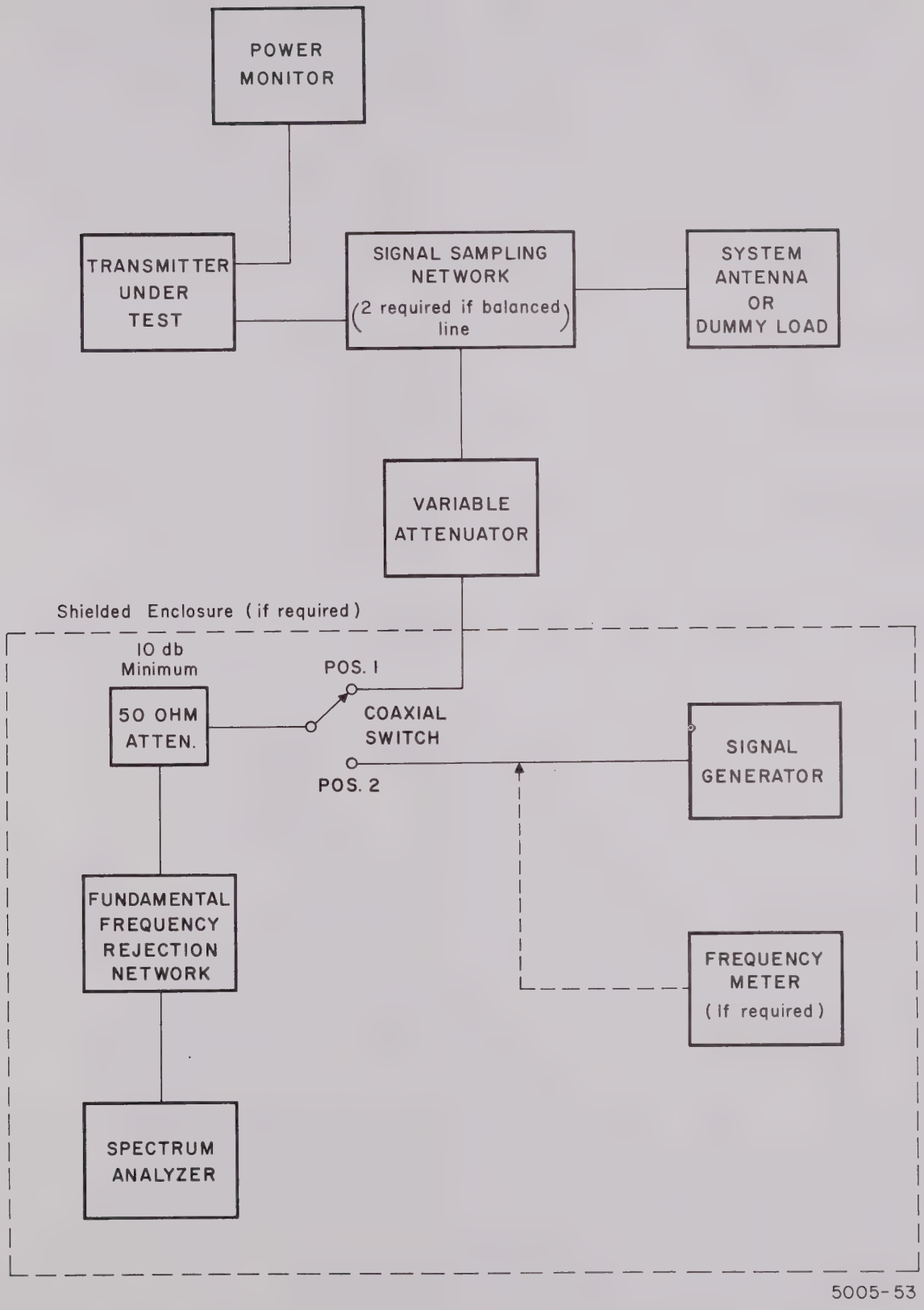


Figure 3-25. Transmitter Output Test Set-up

f. When a spurious signal is found, check its frequency by reading the Tuning Dial.

NOTE

Be sure that spurious responses being measured are not being generated by the analyzer. Refer to paragraph 3-47.

g. Adjust the IF ATTEN 20 DB control for a full scale display of the spurious signal.

h. Set the coaxial switch to position 2 and adjust the signal generator to the same frequency as the spurious signal.

i. Adjust the signal generator output level for a full scale display. Note and record the output level and frequency.

j. Repeat steps b through i scanning the entire frequency band of interest until the frequencies and levels of all spurious signals are located.

3-105. OPTIONAL EQUIPMENT OPERATION.

3-106. CRYSTAL CALIBRATOR OPERATION. The 6.3 VAC filament power is continually applied to the calibrator tubes whenever the analyzer is switched on so that the calibrator is always ready for immediate use. To obtain the desired marker pips, set the R.F. CAL. switch (37, figure 31.) to the corresponding position. Note that the 1 MC and 10 MC markers can only be used when the RANGE switch is in the 10 MC-1KMC position, while the 100 MC markers are usable only when the RANGE switch is in the 3-12 KMC of 12-43 KMC positions. (Refer to paragraph 1-55.)

3-107. The LEVEL control (38, figure 3-1) adjusts the amplitude of the 1 MC and 10 MC marker pips. No level control is required for the 100 MC pips since that circuit is equipped with an additional stage of amplification. Determining the frequency of a specific pip is best accomplished using the variable frequency pip produced by the marker generator. The frequency accuracy of the generator circuit is sufficient to enable the operator to select the proper crystal marker.

3-108. 100 MEGACYCLE SWEEP WIDTH OPERATION. A crystal calibrator is required to

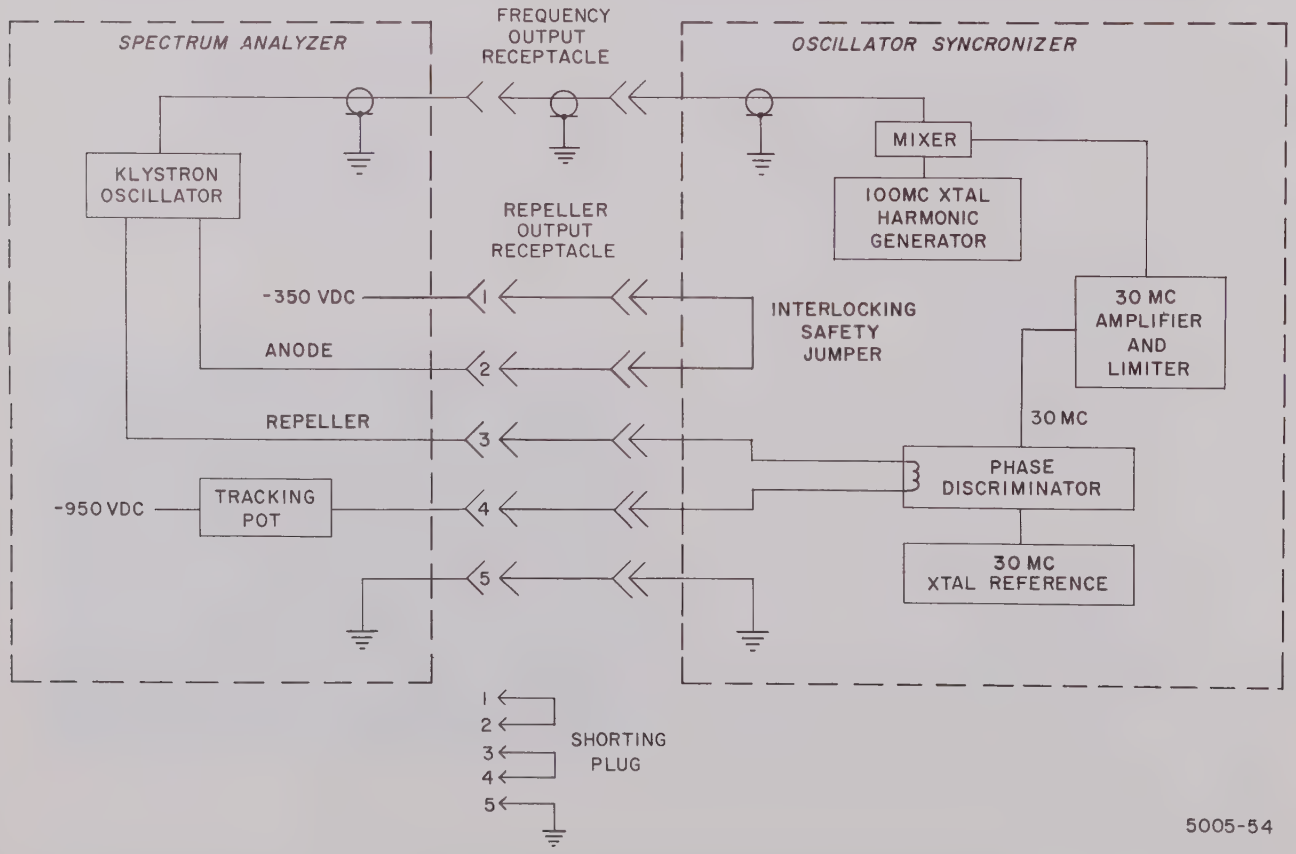


Figure 3-26. Klystron Phase Locking, Equipment Test Set-up

establish sweep widths in excess of the 80 MC limit provided by the marker generator. To adjust the sweep width for a 100 MC scan, inject 10 MC crystal markers and adjust the SWEEP WIDTH control so that there are 5 marker pips on either side of the center pip and so that the outer pips line up with the screen graticule perimeter.

3-109. OSCILLATOR SYNCHRONIZER OPERATION. To provide klystron phase locking, set up a suitable oscillator synchronizer (paragraph 1-59) in accordance with figure 3-26. For specific operating instructions, refer to the applicable manual supplied with the synchronizer.

3-110. MULTIPULSE DECODER OPERATION. The decoder should be connected in series between the front panel IF OUTPUT and IF INPUT receptacles. For specific operating instructions, refer to the applicable manual supplied with the decoder.

3-111. POLAROID CAMERA OPERATION. For specific installation and operation instructions, refer to the manual supplied with the camera assembly.

SECTION 4

THEORY OF OPERATION

4-1. GENERAL.

4-2. The analyzer consists of two major components, the Tuning Head and the Indicator Unit. These components and their subordinate circuits are described at the block diagram level in the following paragraphs. For a more complete picture of component function see the applicable schematic diagrams located at the rear of this manual.

4-3. TUNING HEAD.

4-4. The Tuning Head is a highly selective superheterodyne microwave receiver spanning a frequency range from 10 to 43,000 megacycles in six bands. Its primary function is to receive and convert incoming signals to the 160 ±40 megacycle acceptance frequency of the Indicator Unit.

4-5. The incoming signal is received through one of the front panel input receptacles, either directly or through one of the accessory waveguide adapters. (See figure 4-1.) Signals in the 10 MC — 1 KMC or 1 KMC — 12 KMC ranges can be inserted at the INPUT 10 MC — 12 KMC receptacle or at the applicable ATTEN INPUT receptacle. These attenuated input receptacles are connected internally to two ganged 0-100 db variable attenuators (AT-201 and AT-202) controlled by the RF ATTENUATOR control and are used for signals in excess of -40 dbm. Accessory jumpers are provided to connect the attenuated signal from the applicable ATTEN OUTPUT receptacle to the INPUT 10 MC — 12 KMC receptacle.

4-6. The RF ATTENUATOR control affects only those signals connected to the 10 MC — 1 KMC or 1 KMC — 12 KMC ATTEN INPUT receptacles and has no effect on signals fed directly to either the INPUT 10 MC — 12 KMC or the DIRECT INPUT 12 — 43 KMC input receptacles.

NOTE

Dial calibrations on the RF ATTENUATOR control are for reference only and do not necessarily reflect the actual attenuation provided. Even with the control at the 0 db position, there is a residual attenuation of from 15 to 30 db due to internal losses.

4-7. Signals in the 12 — 43 KMC range must be inserted at the DIRECT INPUT 12 — 43 KMC receptacle using the applicable waveguide accessory adapter listed in table 1-1. Accessory external attenuators are available to attenuate signals in excess of -40 dbm.

4-8. Depending on the frequency, the incoming signal is fed to one of two mixers. Signals in the 10 MC — 12 KMC range are connected to mixer Z201, while signals in the 12 — 43 KMC range are connected to mixer Z202. At the mixer, the signal is heterodyned with the output from either a triode oscillator (V201) or a reflex klystron (V207). Selection of the particular oscillator is determined by the position of the RANGE switch which actuates the switching relays K201 through K205. (For specific oscillator ranges, refer to table 1-3.)

4-9. When the RANGE switch is in the 10 MC — 1 KMC position (Bands 1 and 2) these relays are in the positions shown in figure 4-1. The fundamental frequency (170 — 840 MC) or the third harmonic output from triode oscillator V201 is connected via the normally closed contacts of relay K201 to mixer Z201 where it is heterodyned with the incoming signal to produce a 160 ±40 MC difference frequency. This is the first IF frequency and is fed through the normally closed contacts of relay K203, through a two-stage IF amplifier, and finally, through the normally closed contacts of relays K204 and K205 to the Indicator Unit.

NOTE

Relays K204 and K205 are energized only when the RANGE switch is in the 10 MC — 3 KMC position and the Tuning Dial pointer is below 95 megacycles. When energized, these relays connect a 160 ±5 MC bandpass filter into the circuit.

4-10. When the RANGE switch is in the 3 — 12 KMC position (Bands 3 and 4), relay K201 is energized, disconnecting the triode oscillator V201 and connecting the klystron V207 to mixer Z201. Thus the incomming signal is now heterodyned with either the fundamental (2.4 — 6 KMC) or the second harmonic (4.8 — 12 KMC)

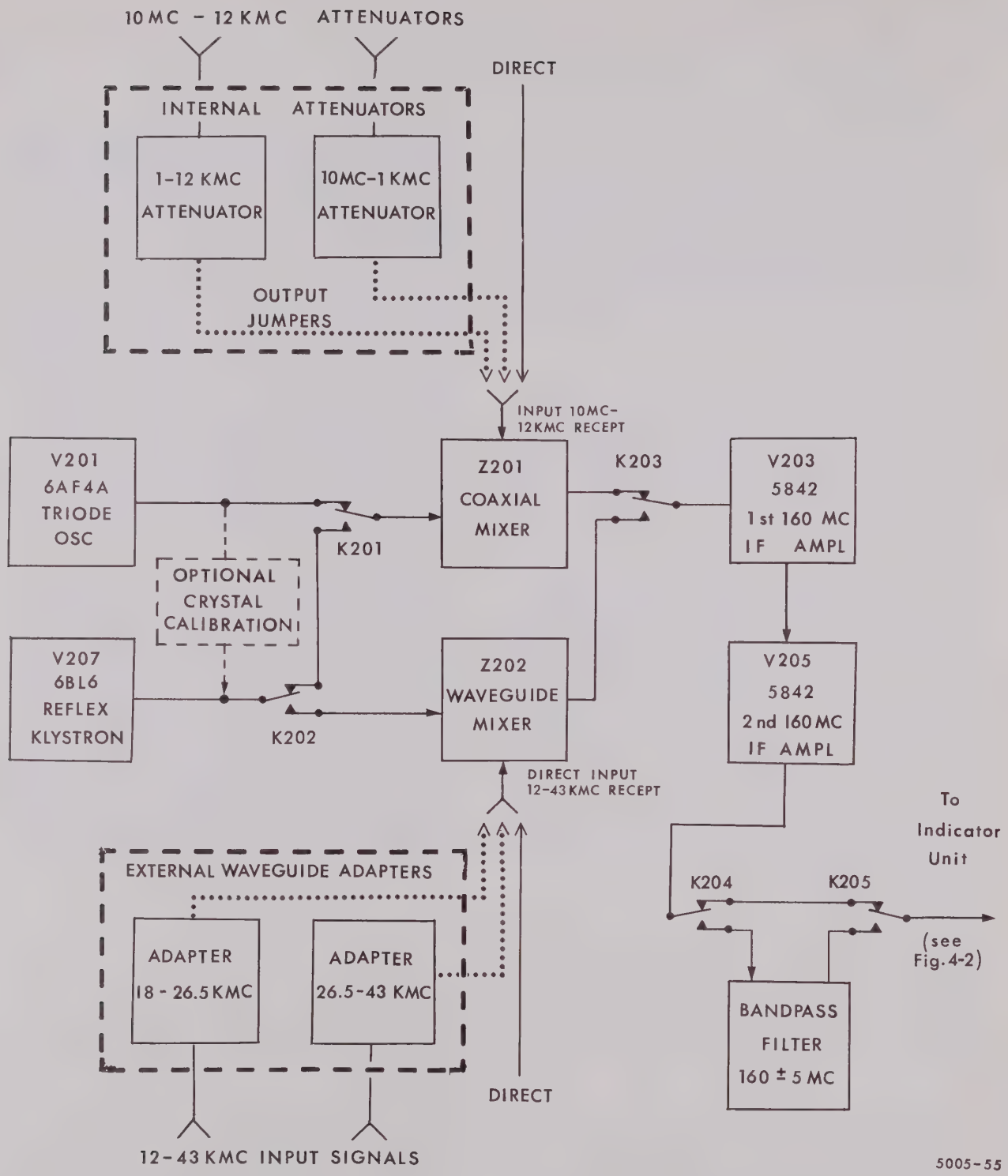


Figure 4-1. Tuning Head, Block Diagram.

klystron frequency to produce the 160 ±40 MC IF frequency. The remaining relays remain in the positions shown in figure 4-1.

4-11. When the RANGE switch is in the 12 — 43 KMC position (Bands 5 and 6), relay K201 is de-energized (returning to the position shown in figure 4-1) and relays K202 and K203 are energized. The fourth and seventh harmonics of the klystron output frequency are now connected through the normally-open contacts of relay K202 to mixer Z202. Here they are heterodyned with the incoming signal from the DIRECT INPUT 12 — 43 KMC waveguide input receptacle to produce the 160 ±40 MC IF frequency. The IF frequency is fed through the normally-open contacts of relay K203, through two stages of IF amplification (V203 and V205) and finally through the normally-closed contacts of relays K204 and K205 to the Indicator Unit.

4-12. INDICATOR UNIT.

4-13. The Indicator Unit is a broad-band scanning, superheterodyne receiver which combines high sensitivity, selectivity, and simplicity of operation. Its primary function is to provide a swept-band spectrum display of the frequency band selected and converted by the Tuning Head. (See figure 4-2.)

4-14. The 160 ±40 megacycle IF signal from the Tuning Head is fed through two stages of IF amplification (V301 and V302) to the second IF mixer (V303). Here it is joined by the output signal from the marker oscillator (V401) and the two signals are heterodyned with the output from the swept oscillator (V307) to produce the 75 megacycle second IF frequency.

4-15. MARKER OSCILLATOR CIRCUIT. The marker oscillator (V401) consists of a conventional marker generator circuit with provision for external modulation. Tuning is accomplished by adjusting the MARKER FREQUENCY control which varies ganged capacitors C403 and C405 in the plate and grid circuits. The output level is controlled by the MARKER LEVEL potentiometer R413 and, in the fully counterclockwise position, opens switch S401 to remove B+ from the marker circuit.

4-16. SWEPT OSCILLATOR CIRCUIT. The swept oscillator (V307) provides the sawtooth-modulated converter frequency which, when heterodyned with the input and marker generator signals, produces the spectral sweep displayed on the CRT screen. A sawtooth voltage, produced by the sync amplifier (V801) and sawtooth generator (V802) circuits, is applied to the control winding of the inductor controlling oscillator frequency. The frequency excursion (sweep width) of the oscillator is determined by the amplitude of the sawtooth signal which is, in turn, controlled by the position of the SWEEP WIDTH potentiometer R873. The rate of oscillator sweep is determined by the sawtooth frequency which is controlled by the position of the SWEEP RATE potentiometer R825B.

4-17. SYNC AMPLIFIER CIRCUIT. The sawtooth signal, which modulates the swept oscillator, originates with the synchronizing signal (normally a sine wave) selected by the CAL SYNC SEL switch S801. When this switch is in the LINE or CAL position the 60 cycle line frequency is applied to the first grid of the duo-triode sync amplifier V801. The sync amplifier (V801) amplifies and differentiates the synchronizing signal, shaping it into positive-going pulses which are developed across the SYNC AMPL potentiometer R815. Some distortion of the sine wave is normal and does not affect the operation of the set.

4-18. SAWTOOTH GENERATOR CIRCUIT. The sawtooth generator circuit consists of the sawtooth generator V802, the cathode follower V803 and neon lamp E801. The sawtooth generator functions as a Miller-type sweep generator with the RC network (C809, R823, R825A, R827, R825B, and R831) in the grid. circuit determining the base time constant.

4-19. The sweep circuit is triggered by the pulses from the sync amplifier developed across the SYNC AMPL potentiometer R815. These pulses are applied to the electrostatic coating on the neon lamp E801 to change its firing level. The signal from the sawtooth generator (V802) is applied to the cathode follower V803 which serves as a feedback and output stage. The output signal at this point is a sawtooth voltage which is distributed to the sawtooth driver (V306) to regulate the swept oscillator and to the horizontal amplifier (V804) to drive the CRT horizontal sweep. Since both the oscillator and CRT horizontal sweep are thus synchoronized, the CRT display represents an accurate picture of signal frequency with respect to sweep width.

4-20. SECOND IF STAGE CIRCUITS. The sawtooth-modulated output from the triode mixer V303 is fed through a 75 MC bandpass filter network to the IF ATTENUATOR network consisting of switches S301 through S306 and resistors R349 through R366. This attenuator network provides from 0 to 40 db of IF attenuation in 1 db increments.

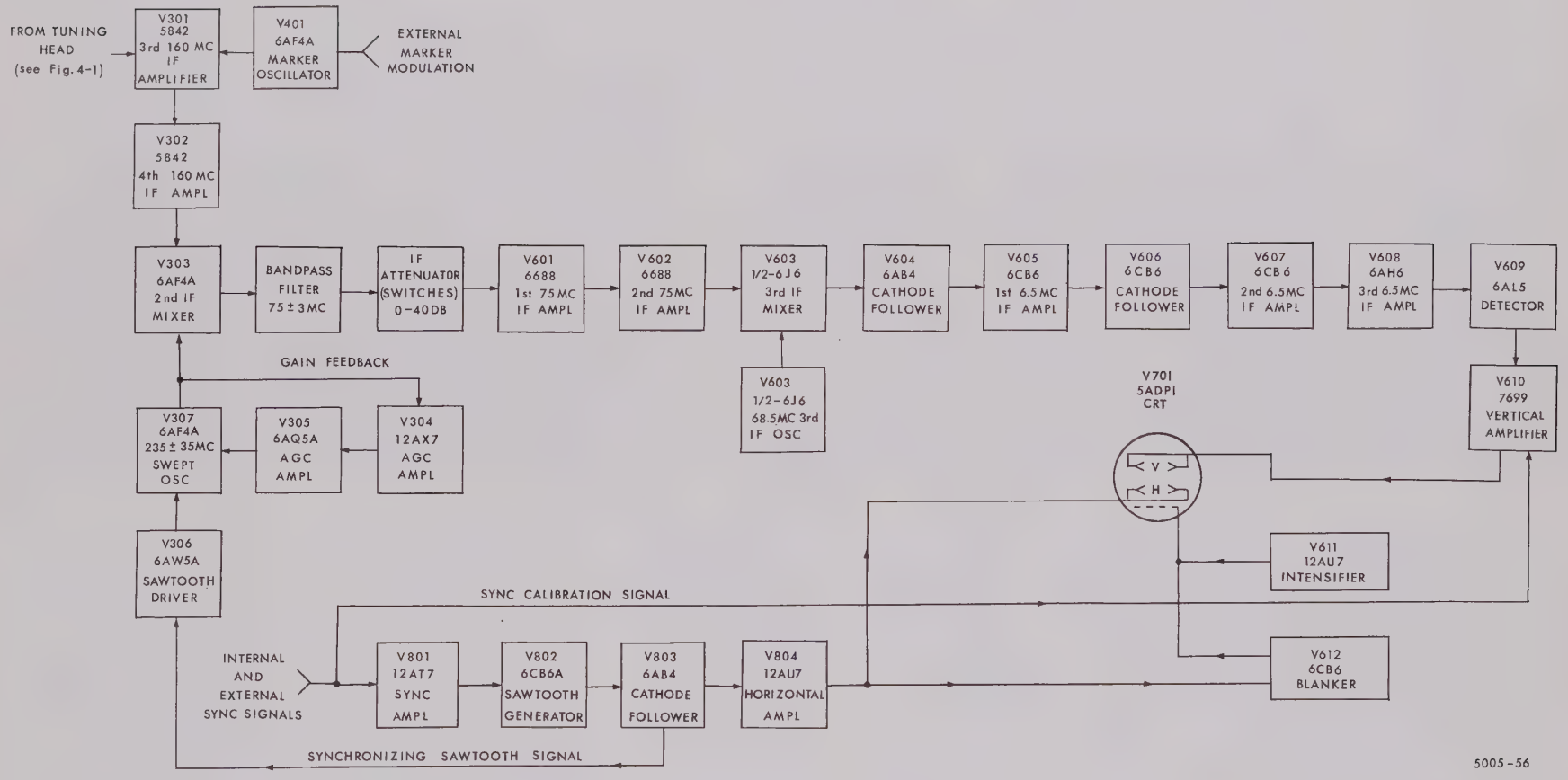

FROM TUNING HEAD (see Fig. 4-1)
V301 5842 3rd 160 MC IF AMPLIFIER
V401 6AF4A MARKER OSCILLATOR
EXTERNAL MARKER MODULATION
V302 5842 4th 160 MC IF AMPL
V303 6AF4A 2nd IF MIXER
BANDPASS FILTER 75 ± 3MC
IF ATTENUATOR (SWITCHES) 0-40DB
V601 6688 1st 75MC IF AMPL
V602 6688 2nd 75MC IF AMPL
V603 1/2-6J6 3rd IF MIXER
V604 6AB4 CATHODE FOLLOWER
V605 6CB6 1st 6.5MC IF AMPL
V606 6CB6 CATHODE FOLLOWER
V607 6CB6 2nd 6.5MC IF AMPL
V608 6AH6 3rd 6.5MC IF AMPL
V609 6AL5 DETECTOR
GAIN FEEDBACK
V603 1/2-6J6 68.5MC 3rd IF OSC
V701 5ADP1 CRT
V610 7699 VERTICAL AMPLIFIER
V307 6AF4A 235 ± 35MC SWEPT OSC
V305 6AQ5A AGC AMPL
V304 12AX7 AGC AMPL
V306 6AW5A SAWTOOTH DRIVER
V611 12AU7 INTENSIFIER
SYNC CALIBRATION SIGNAL
INTERNAL AND EXTERNAL SYNC SIGNALS
V801 12AT7 SYNC AMPL
V802 6CB6A SAWTOOTH GENERATOR
V803 6AB4 CATHODE FOLLOWER
V804 12AU7 HORIZONTAL AMPL
V612 6CB6 BLANKER
SYNCHRONIZING SAWTOOTH SIGNAL
5005-56

Figure 4-2. Indicator Unit, Block Diagram.

4-21. The output from the attenuator in coupled through a tuned LC circuit to the first grid of the two second IF (75 MC) amplifiers (V601 and V602). The IF ATTEN 20 DB potentiometer R612 connected to the cathode circuit of both tubes controls the gain of both amplifiers and provides from 0 to 20 db of attenuation.

4-22. THIRD IF MIXER-OSCILLATOR CIRCUIT. The output from the second (75 MC) amplifier is applied to the grid (pin 6) of one-half of the mixer-oscillator V603. In the plate circuit, the signal is mixed with the output of the third IF oscillator (1/2 V603) to produce the 6.5 MC third IF frequency.

4-23. THIRD IF AMPLIFIER CIRCUIT. The 6.5 MC signal from the third IF mixer (1/2 V603) is amplified through a two-stage third IF amplifier circuit consisting of cathode followers V604 and V606 and pentode RF amplifiers V605, V607, and V608. The crystals CR601 and CR602 serve to peak the response curve of these stages. The bandwidth of this stage is controlled by the IF BANDWIDTH control (dual potentiometer R631-R698) which controls the Q of tuned inductors L611 and L613 in their respective pentode grid circuits.

4-24. DETECTOR CIRCUIT. The output from the third IF amplifier circuit is applied to an untuned detector circuit which provides a linear, logarithmic, or exponential signal response. Selection of the desired response mode is made using the three-stage AMPLITUDE SCALE switch S601. When the switch is set to the LIN position, pentode amplifier V608 acts as a simple linear amplifier whose output is detected by the diode detector V609.

4-25. With the switch in the LOG position, a negative portion of the detected signal voltage is fed back to amplifier V608 as degenerative grid bias. This bias voltage is proportional to signal level and, as the bias increases, the gain of the amplifier decreases. Accordingly, high level signals will be amplified to a lesser degree than low level signals and will, consequently, appear compressed. The degree of signal compression is determined by the position of the LOG 0 DB potentiometer R659 which is used to shape the Ip curve of the amplifier V608 to conform to the log zero position on the CRT graticule.

4-26. In the PWR position, a positive portion of the detected signal voltage is fed back as regenerative grid bias. This bias voltage is proportional to signal level and, as the bias increases, the gain of the amplifier also increases. Accordingly, high level signals will be amplified to a greater degree than low level signals and, consequently, will appear expanded. Resistor values have been selected such that a square law characteristic curve is obtained. Adjustment of this curve is made using potentiometer R657.

4-27. VIDEO AMPLIFIER CIRCUIT. The video amplifier circuit consists of the phase inverter and push-pull vertical amplifier (V610), the intensifier (V611), and the CRT blanking amplifier (V612). The output signal from the 6.5 MC detector (V609) is amplified in the first half of the vertical amplifier (V610) and applied to one of the CRT vertical deflection plates. A portion of the output signal is also inverted in phase, amplified in the second half of the vertical amplifier (V610) and applied to the other CRT vertical deflection plate.

4-28. VIDEO FILTER CIRCUIT. Rotating the VIDEO FILTER control clockwise from the fully counterclockwise position actuates switch-potentiometer R667 which in conjunction with capacitor C671 forms a low-pass filter to remove high frequency noise from the grid circuit of vertical amplifier V610.

4-29. INTENSIFIER CIRCUIT. A segment of the output signal from the vertical amplifier V610 is fed to the grid of one half of V611. In response to tube conduction a positive voltage is developed across the INTENSIFIER potentiometer R686 which is proportional to video signal amplitude. A portion of this positive voltage is picked off by the potentiometer arm and applied to the control grid of the CRT V701. Accordingly, when a high amplitude signal is present at the vertical deflection plates, a porportionally high positive voltage from the intensifier is present at the CRT control grid. This intensifier voltage serves to increase the brightness of high amplitude signal peaks by increasing tube conduction. Control of intensifier voltage is obtained by positioning the INTENSIFIER potentiometer R686.

4-30. The blanking amplifier (V612) receives a sawtooth signal from the horizontal amplifier (V804) and differentiates it to produce a pulse which blanks out the sweep during the retrace time.

4-31. POWER SUPPLY CIRCUITS. All of the voltages required by the analyzer are furnished by internal power supply circuits powered by the nominal 115 volt, 60 cycle external source. The low voltage supplies are conventional electronically regulated types supplying voltages of -150, -12 and +250 volts DC

and 6.3 volts AC. The +250 volt B+ supply is exceptionally well regulated.

4-32. CRT POWER SUPPLY. The high voltage for the CRT is produced by an RF type power supply to permit the use of smaller and lighter components. Tube V114 acts as a power oscillator at a frequency of approximately 100 kilocycles. The oscillator output is stepped up across transformer T103 and rectified by diodes CR133A and CR135 to produce the +2400 and -2400 voltages required for the CRT.

4-33. KLYSTRON POWER SUPPLY. The high voltages required by the klystron are derived from a special power supply consisting of a diode full-wave bridge rectifier, a series regulator (V108), four voltage regulators (V110, V111, V112, and V113), and a DC amplifier V109. The output from this supply is the -950 volts required for repeller tracking and the -350 volts applied to the klystron cathode.

SECTION 5

MAINTENANCE

5-1. GENERAL.

5-2. This section of the manual is designed to assist in the maintenance, testing, repair, and calibration of the analyzer. No attempt to remove, repair, or adjust internal equipment components should be made until the operator is thoroughly familiar with the information contained in this section.

5-3. Despite its simplicity of operation, the analyzer is an extremely complex electronic device. While equipment components have been carefully selected for reliability, some degradation of component performance and occasional failure of detail parts due to aging is to be expected. As with all high frequency equipment of this type, the installation and adjustment of many internal components is highly critical and repair or replacement of certain detail parts may entail extensive realignment and recalibration.

5-4. These procedures require trained maintenance personnel with a high degree of specialized knowledge and experience in servicing equipment of this type together with a substantial amount of specialized test equipment. Accordingly, equipment users who do not possess the requisite maintenance facilities may not wish to attempt them.

5-5. Specially trained maintenance personnel and all the necessary test equipment are available at the Service Department of The Singer Company, Metrics Division. If a trouble develops which cannot be corrected by the procedures described in the following paragraphs, it is recommended that the analyzer be returned to the manufacturer for servicing.

WARNING

Dangerous voltages are encountered while performing maintenance procedures. To avoid contact with lethal voltage, personnel should observe proper safety precautions.

5-6. TEST EQUIPMENT AND SPECIAL TOOLS.

5-7. The test equipment and special tools required for maintenance of the analyzer are listed in table 5-1.

TABLE 5-1. RECOMMENDED TEST EQUIPMENT AND SPECIAL TOOLS

ITEM	NOMENCLATURE	TYPE	RANGE	MANUFACTURER	MODEL
1	Signal Generator	VHF	10-420 MC	The Singer Company, Metrics Division	SG-9
2	Signal Generator	UHF	400-1200 MC	The Singer Company, Metrics Division	SG-10
3	Signal Generator	L Band	900-2200 MC	The Singer Company, Metrics Division	SG-11
4	Signal Generator	S Band	1800-4400 MC	The Singer Company, Metrics Division	SG-12
5	Signal Generator	C Band	3800-7600 MC	The Singer Company, Metrics Division	SG-13
6	Signal Generator	X Band	7000-11,000 MC	The Singer Company, Metrics Division	SG-14

TABLE 5-1. RECOMMENDED TEST EQUIPMENT AND SPECIAL TOOLS (Cont.)

ITEM	NOMENCLATURE	TYPE	RANGE	MANUFACTURER	MODEL
7	Frequency Doubler	Ku/K Band	18,000-26,500 MC	Hewlett-Packard	938A
8	Frequency Doubler	Ka Band	26,500-40,000 MC	Hewlett-Packard	940A
9	Oscillator	Wideband	5 cps — 600 KC	Hewlett-Packard	200CD
10	Wavemeter			FXR	N410A
11	Wavemeter	S Band	3.95 — 5.84 KMC	Polytechnic R &D	532
12	Wavemeter	C Band	5.85 — 8.2 KMC	Polytechnic R & D	533
13	Wavemeter	X Band	8.2 — 12.4 KMC	Polytechnic R & D	535
14	Termination	--	50 ohm	Microlab	TN50M
15	Sweep Generator	Wideband	0.5 — 900 MC	Telonic	HD-1A
16	Multimeter	--	---	Triplett	630
17	VTVM	--	---	The Singer Company, Metrics Division	9101
18	Oscilloscope	--	---	Tektronix	545
19	Klystron Repeller Mode Modulator	--	---	See figure 5-27	---
20	Step Attenuator	--	---	Kay	30
21	Crystal Calibrator	--	.25, 1, 10 MC marker pips	Measurements, Inc.	100
22	Frequency Counter	--	1-100 MC range (minimum)	Hewlett-Packard	524D
23	Power Supply	--	250 VDC @60 MA & 6.3 VAC @ 2 amperes	Lambda Electronics	25
24	Power Meter	--	0-10 MW capacity	The Singer Company, Metrics Division	9301
25	Thermistor Mount	--	10 MW capacity (minimum)	The Singer Company, Metrics Division	AB-103
26	Milliammeter	--	0-60 MA (minimum)	(Standard)	

5-8. MINIMUM PERFORMANCE STANDARDS CHECKS.

5-9. The Minimum Performance Standards Checks described in paragraphs 5-10 through 5-28 are a group of functional tests designed to indicate whether the analyzer is functioning properly and, if not, to indicate a general area of failure. These checks are arranged in sequence so that each adds a minimum number of new circuits to be evaluated. Should the analyzer fail to meet the requirements of an individual check, refer to the Troubleshooting Procedures described in paragraphs 5-29 through 5-41 and listed in table 5-2.

5-10. POWER-SCALE ILLUMINATION CHECK. This procedure checks the operation of the input power and scale illumination circuits controlled by the POWER SCALE ILLUM control.

a. Rotate the POWER SCALE ILLUM control clockwise until an audible click indicates that the switch detent has been passed. Note that one of the tuning dial bands is illuminated.

b. Rotate the POWER SCALE ILLUM control fully clockwise and note that the CRT graticule edge-lighting increases to maximum brightness.

c. Adjust the POWER SCALE ILLUM control so that the graticule lines are only faintly illuminated.

NOTE

The equipment must have warmed up for a minimum of ten minutes before the following checks may be performed.

5-11. BASELINE TRACE CHECK. This procedure checks the operation of the CRT and power supply circuits.

a. Set the BRILLIANCE control to a two-thirds maximum clockwise position.

b. Rotate the POWER SCALE ILLUM switch fully counterclockwise (OFF) then fully clockwise. Note that the baseline trace appears within 30 seconds.

5-12. BRILLIANCE CHECK. This procedure checks the operation of the CRT brilliance circuit.

a. Rotate the BRILLIANCE control fully counterclockwise and note that the sweep trace dims and disappears.

b. Rotate the BRILLIANCE control fully clockwise and note that the sweep trace increases smoothly to its maximum brightness.

c. Adjust the BRILLIANCE control for a sharp, bright trace.

NOTE

During this check, the sweep trace focus may vary; this condition is normal.

5-13. ASTIGMATISM CHECK. This procedure checks the operation of the CRT astigmatism correction circuit.

a. Rotate the ASTIG adjusting screw from fully counterclockwise to fully clockwise and note that the baseline focus becomes uneven at opposite ends.

b. Adjust the ASTIG adjusting screw for an even degree of focus across the entire baseline.

5-14. FOCUS CHECK. This procedure checks the operation of the CRT focus circuit.

a. Rotate the FOCUS control from fully counterclockwise to fully clockwise and note that the CRT sweep trace changes from blurred to sharp to blurred.

b. Adjust the FOCUS control for the sharpest trace.

NOTE

If the sweep trace can be sharply focused only at one end at a time, readjust the ASTIG control for an equal degree of focus at both ends of the sweep and repeat step b.

5-15. HORIZONTAL POSITIONING CHECK. This procedure checks the operation of the baseline horizontal positioning circuit.

a. Rotate the H POS adjusting screw from fully counterclockwise to fully clockwise and note that the baseline moves from the extreme left hand side of the CRT screen to the extreme right hand side.

b. Adjust the H POS adjusting screw to center the baseline on the CRT.

NOTE

It may be necessary to reduce the length of the baseline temporarily in order to perform this adjustment. Rotate the LINE SIZE adjusting screw in a counterclockwise direction to reduce baseline length.

5-16. LINE SIZE CHECK. This procedure checks the operation of the baseline length adjusting circuit.

a. Rotate the LINE SIZE adjusting screw from fully counterclockwise to fully clockwise and note that the baseline length increases from minimum to maximum.

b. Adjust the LINE SIZE adjusting screw so that the baseline extends approximately 1/8 inch beyond each side of the engraved graticule.

5-17. SWEEP RATE AND SYNC AMPLITUDE CHECK. This procedure checks the sweep rate and synchronizer amplitude circuits.

a. Set the CAL SYNC SEL switch to the CAL position and rotate the SYNC AMPL control fully counterclockwise.

b. Rotate the SWEEP RATE control fully clockwise, then slowly counterclockwise to obtain a single sine wave presentation.

NOTE

This presentation is one cycle of the line frequency and indicates a 60 cps sweep rate. Note that the sine wave appears almost stationary with a slight drift to the left. When in the CAL mode some distortion of the sine wave presentation will be experienced. This condition is normal.

c. Slowly rotate the SYNC AMPL control in a clockwise direction until the presentation becomes almost steady.

NOTE

Further rotation of the SYNC AMPL control will tend to shorten the length of the baseline trace. The optimum setting of the SYNC AMPL control is the minimum sync amplitude consistent with a stationary display.

d. Continue to rotate the SWEEP RATE control in a counterclockwise direction and obtain a 2-cycle presentation (30 cps sweep), a 3-cycle presentation (20 cps sweep), and a 4-cycle presentation (15 cps sweep). Adjust the SYNC AMPL control as required to obtain a steady presentation in each case.

NOTE

A typical screen presentation showing two cycles of line frequency and indicating a sweep rate of 30 cps (25 cps for 50 cps power line frequency) is illustrated in figure 5-1. The sweep rate at any position is equal to the line frequency (normally 60 cps) divided by the number of cycles visible. At low sweep rates it is easier to count sweeps, using a stopwatch, rather than to count cycles. A 1-second sweep should be reached just before the maximum counterclockwise position of the SWEEP RATE control.

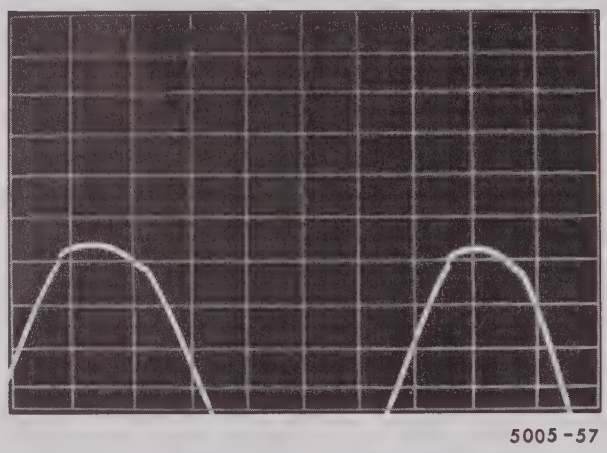


Figure 5-1. Calibration Signal Synchronized at 30 cps

5-18. PRELIMINARY CONTROL SETTINGS. For each of the following checks, reset the operating controls to the preliminary positions indicated in the following tabulation:

CONTROL	POSITION
SWEEP WIDTH	Fully clockwise
IF BANDWIDTH	Fully clockwise
BRILLIANCE	Desired trace brightness
INTENSIFIER	Fully counterclockwise

CONTROL	POSITION
FOCUS	Sharp trace
SPECTRUM CENTERING	Center
AMPLITUDE SCALE	LIN
IF ATTENUATOR (Toggle Switches)	Down position (no attenuation)
IF ATTEN 20 DB	1/8 inch noise on CRT (Refer to paragraph 5-19)
CAL SYNC SEL	LINE
SWEEP RATE	30 cps (2-cycle presentation) (Refer to NOTE following step f; paragraph 5-17.)
SYNC AMPL	Stable presentation
VIDEO FILTER	Fully counterclockwise
MARKER FREQUENCY	0
MARKER LEVEL	OFF
RANGE	10 MC — 3 KMC
INTERNAL CHECK	XTAL BIAS
TUNING	As required by applicable paragraphs
RF ATTENUATOR	100

5-19. IF ATTEN 20 DB CONTROL CHECK. This procedure checks the operation of the IF ATTEN 20 DB control. Note that counterclockwise rotation of this control increases the gain of the IF amplifiers in the equipment.

a. Set the operating controls to the positions indicated in paragraph 5-18.

b. Rotate the IF ATTEN 20 DB control fully clockwise.

c. Slowly rotate the IF ATTEN 20 DB control to the fully counterclockwise position. Note that the noise level displayed on the CRT increases from zero to from 1/8 to 1/2 of full scale deflection.

NOTE

For normal operation, the IF ATTEN 20 DB control should be adjusted for 1/16 to 1/8 inch of noise on the CRT when the other controls are set to the positions indicated in paragraph 5-18.

5-20. MARKER AND SPECTRUM CENTERING CHECK. This procedure checks the operation of the frequency marker and spectrum centering circuits.

a. Set the operating controls to the positions indicated in paragraph 5-18 and allow a 30 minute warmup.

b. Set the IF ATTENUATOR 10 DB switch to the IN position and adjust the IF ATTEN 20 DB control for 1/8 inch of noise deflection on the CRT.

c. Rotate the MARKER LEVEL control clockwise until a full scale marker pip appears on the CRT.

d. Check that the SWEEP WIDTH control is fully clockwise and the SPECTRUM CENTERING and MARKER FREQUENCY controls are centered. Adjust the H POS adjusting screw to position the marker pip at the center (-0+) vertical line on the screen graticule.

e. Set the MARKER FREQUENCY control to the +40 megacycle position (left end of the MARKER dial) and adjust the LINE SIZE adjusting screw to align the marker pip with the extreme right vertical line on the screen graticule.

f. Rotate the MARKER FREQUENCY control from the +40 to the -40 megacycle position. Note that the marker pip travels across the screen to the extreme left vertical line on the screen graticule (±1/2) screen division).

g. Set the MARKER FREQUENCY control to the 0 megacycles position and note that the marker pip coincides with the center (-0+) vertical line on the screen graticule (±1/4 screen division).

h. Rotate the SWEEP WIDTH control fully counterclockwise (minimum sweep width) keeping the marker pip centered by adjusting the SPECTRUM CENTERING control. Note that this counterclockwise setting of the SWEEP WIDTH control causes the marker pip to appear as an expanded pip display. (See figure 5-2.)

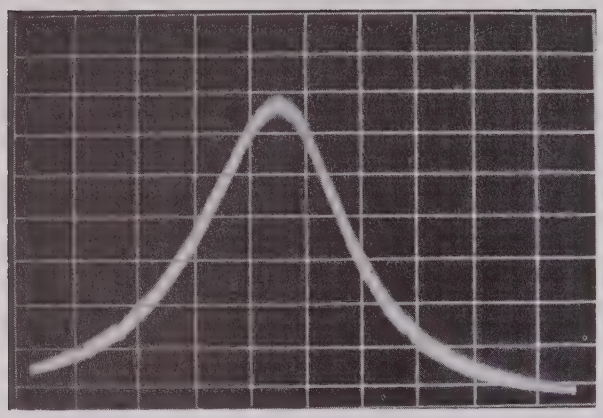


Figure 5-2. Expanded Pip Display

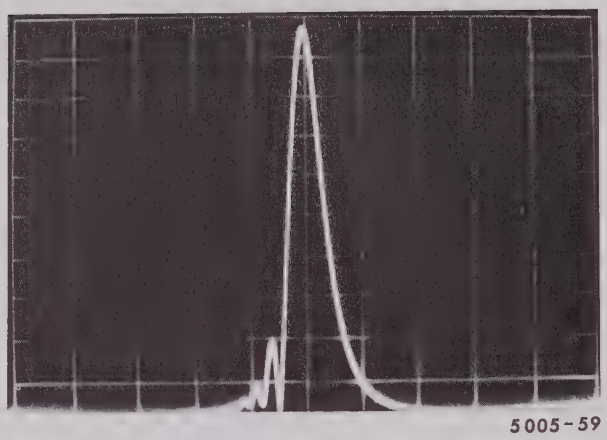


Figure 5-3. Optimum Resolution

5-21. IF BANDWIDTH CHECK. This procedure checks the operation of the IF bandwidth circuit.

a. Set the operating controls to the positions indicated in paragraph 5-18.

b. Adjust the MARKER LEVEL control for full scale marker pip deflection.

c. Rotate the SWEEP WIDTH control fully counterclockwise.

d. Adjust the SPECTRUM CENTERING control as required to center the marker pip.

e. Slowly rotate the IF BANDWIDTH control in a counterclockwise direction and note that the pip width decreases.

NOTE

At this time a change in pip height may occur. Rotation of the IF BANDWIDTH control through its full range will result in a major change in pip height. Also, small convolutions or "ringing" will appear on the trailing (left) edge of the pip. Optimum resolution occurs when the first convolution beyond the apex of the pip appears. (See figure 5-3).

5-22. VIDEO FILTER CHECK. This procedure checks the operation of the video filter circuit.

a. Set the operating controls to the positions indicated in paragraph 5-18, except set the SWEEP WIDTH control fully counterclockwise.

b. Adjust the SWEEP RATE control for 12 cps (5 sine waves).

c. Adjust the MARKER LEVEL control for a half scale pip and slowly rotate the VIDEO FILTER control in a clockwise direction. Note that the CRT noise becomes filtered (disappears) and the marker pip integrates and shifts slightly. The filtering effect will increase as the VIDEO FILTER control is turned to a more clockwise position.

NOTE

In normal operation, the VIDEO FILTER control should be positioned to give the clearest CRT presentation consistent with a minimum loss of signal amplitude.

5-23. INTENSIFIER CHECK. This procedure checks the operation of the intensity circuit.

a. Set the operating controls to the positions indicated in paragraph 5-18 except set the SWEEP WIDTH CONTROL 1/2 clockwise.

b. Adjust the MARKER LEVEL control for a full scale pip and rotate the BRILLIANCE control counterclockwise until the left hand side of the baseline just disappears.

c. Rotate the INTENSIFIER control clockwise until the marker pip appears. Note that the marker pip is easily discernable although the baseline may not be visible.

NOTE

This check should not be performed where the ambient light is excessive or where direct light is allowed to fall on the CRT screen. (It may also be necessary to reduce the setting of the BRILLIANCE control.)

5-24. AMPLITUDE SCALE CHECK. This procedure checks the amplitude scale circuit, first in the linear, then in the logarithmic and power scale modes.

a. Set the operating controls to the positions indicated in paragraph 5-18.

b. Rotate the SWEEP WIDTH control 1/4 travel clockwise from the fully counterclockwise position.

c. Adjust the TUNING control for 680 megacycles on the bottom scale of the tuning dial.

d. Connect a 160 megacycle, 1000 microvolt signal from the signal generator to the 10 MC -- 12 KMC input receptacle.

e. Adjust the IF ATTEN 20 DB control and the IF ATTENUATOR switches as required to obtain a full scale pip on the CRT.

f. Adjust the signal generator output frequency until the CRT pip appears at the left side of the baseline.

g. Reduce the signal generator output voltage to zero in 100 microvolt steps and note that the decrease in pip amplitude is linear (i.e. 0.9 for a 900 microvolt input, 0.8 for an 800 input, etc.). These decreases in amplitude correspond to the VOLTAGE (LIN) screen calibrations on the right hand side of the screen and should be within ±5% ($\frac{1}{2}$ scale division.)

h. Set the AMPLITUDE SCALE switch to the LOG position and adjust the signal generator for an output of -40 dbm. Adjust the IF ATTEN 20 DB control and the IF ATTENUATOR switches to obtain a full scale pip.

i. Reduce the signal generator output to -60 dbm and note that the pip height decreases to the -20 DB screen calibration (midscale) within ± 2 db.

j. Reduce the signal generator output to -80 dbm and note that the pip height decreases to the -40 DB screen calibration (next to the bottom line) within ± 2 db.

k. Rotate the IF ATTEN 20 DB control fully clockwise and set all the IF ATTENUATOR toggle switches to the IN (up) position.

l. Connect a Kay step attenuator in series with the signal generator output (no attenuation) and adjust the generator output for a full scale signal pip.

m. Insert 20 db of attenuation using the Kay attenuator and set the IF ATTENUATOR 20 DB switch to the down position. Note that the signal pip remains at full scale within ± .05 db per db of attenuation. Repeat with remaining switches.

n. Set the AMPLITUDE SCALE switch to the PWR position and adjust the signal generator for a 1000 microvolt output. Adjust the IF ATTEN 20 DB control and the IF ATTENUATOR switches to obtain a full scale pip.

o. Reduce the signal generator output to 700 microvolts and note that the pip height drops to approximately mid-scale.

5-25. TUNING CONTROL CHECK. This procedure checks the mechanical linkage between the TUNING control and the tuning dial pointer.

a. Rotate the TUNING control back and forth through its complete range. Note that the tuning dial pointer moves smoothly without binding.

b. Rotate the TUNING control from fully counterclockwise to fully clockwise. Note that the tuning dial pointer moves from slightly beyond the left end of the tuning scale to slightly beyond the right end.

5-26. RANGE AND INTERNAL CHECK SWITCH CHECK. This procedure checks the operation of the RANGE and INTERNAL CHECK switches, the internal check meter, and the indicated meter circuits.

a. Set the operating controls to the positions indicated in paragraph 5-18.

b. With the RANGE switch in the 10 MC — 3 KMC position, rotate the INTERNAL CHECK switch clockwise through the six positions. Compare the INTERNAL CHECK meter indications at each switch position with the indications listed in table 5-3.

c. Repeat step b with the RANGE switch in the 3 — 12 KMC and 12 — 43 KMC positions.

5-27. DIRECT INPUT CHECK. This operation checks the frequency accuracy, and sensitivity of the Tuning Head.

a. Set the operating controls to the positions indicated in paragraph 5-18.

b. Adjust the MARKER LEVEL control for a marker pip 1/4 of full scale.

c. Connect the output of the signal generator calibrated at -40 dbm to the 10 MC — 12 KMC input receptacle.

d. Set the RANGE switch to the position corresponding to the frequency range of the selected signal generator frequency.

e. Adjust the TUNING control so that the tuning dial pointer indicates the same frequency as the signal generator input signal. Note that the input signal pip now appears on the CRT screen.

f. Adjust the output attenuation of the signal generator to achieve a 1/2 scale signal pip.

NOTE

If more than one pip (other than the marker) appears, determine which pip represents the true signal using the method described in paragraph 3-56.

g. Adjust the MARKER FREQUENCY control to superimpose the marker pip over the signal pip. Note the deviation indicated by the MARKER dial. This should be within the combined tolerances of the tuning dial and the signal generator.

h. Disconnect the signal generator from the 10 MC — 12 KMC INPUT receptacle and connect the signal generator to the DIRECT INPUT 12-43 KMC input receptacle.

i. Repeat steps d. through g.

5-28. MAXIMUM SENSITIVITY CHECK. This procedure checks the sensitivity of the analyzer (signal-to-noise ratio measured in dbm) with the minimum sweep width and maximum resolution obtainable. Perform the following steps:

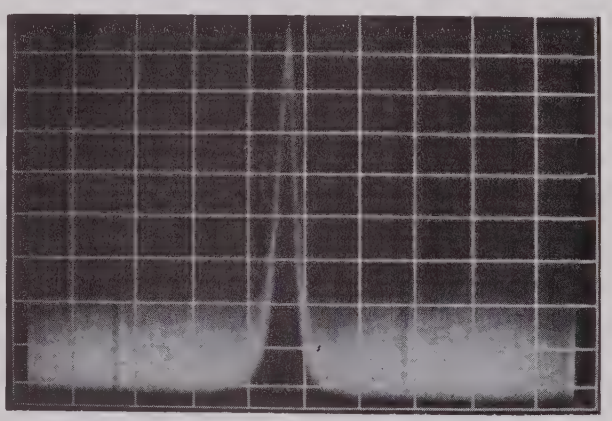
a. Set the operating controls to the positions indicated in paragraph 5-18 except set the IF ATTEN 20 DB control fully counterclockwise. Set the TUNING control to 10 MC.

b. Connect a calibrated signal generator to the 10 MC — 12 KMC INPUT receptacle and inject a 10 MC CW test signal. Center the signal on the CRT screen using the SPECTRUM CENTERING control. (See figure 5-4.)

c. Slowly rotate the SWEEP WIDTH control counterclockwise while optimizing resolution with the IF BANDWIDTH control. Continue to adjust these controls until the point of maximum sensitivity (greatest signal amplitude) is reached. (On the klystron bands, this point is reached just before "FM breakup" appears on the CRT. See figure 5-5.)

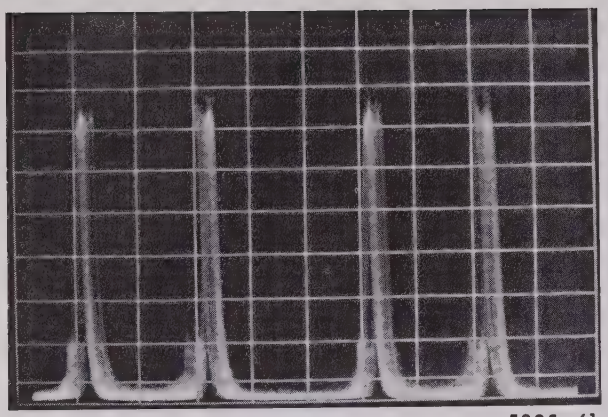
d. Using the signal generator output attenuator, reduce the pip amplitude to the point where the signal equals twice the height of the noise. (See figure 5-6).

e. Note and record the analyzer sensitivity (in dbm) on the signal generator scale.



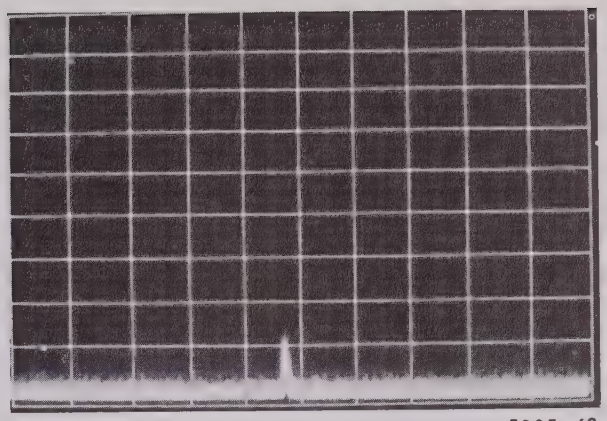
5005-60

Figure 5-4. Signal Pip Centered on Screen



5005-61

Figure 5-5. FM Breakup



5005-62

Figure 5-6. Screen Display at 2:1 Signal-to-Noise Ratio

NOTE

Observe that the criterion used in determining analyzer sensitivity is the ratio between signal and noise. The total amount of noise on the screen is irrelevant as long as a 2:1 signal-to-noise ratio is maintained.

f. To establish a complete sensitivity curve for the analyzer, repeat steps a. through e. at each numbered frequency point on the tuning dial. Adjust the signal generator and TUNING control to each new frequency, switching bands and input receptacles where required. (For maximum and minimum sensitivity ratings for all bands, refer to table 1-3.)

5-29. TROUBLE SHOOTING.

5-30. The troubleshooting procedures are provided to assist maintenance personnel in locating defective components or circuits. They should be performed whenever the analyzer fails to meet one or more of the Minimum Performance Standards Checks or otherwise indicates an internal failure. These procedures are described in table 5-2.

TABLE 5-2. TROUBLESHOOTING

SYMPTOM	PROBABLE TROUBLE	CORRECTION
1. No illumination on the screen when POWER SCALE ILLUM switch is turned to the ON position. Pilot lamp does not light.	AC power is not being supplied to the power supply or the indicator.	Check interconnecting Cables.
		Check for input voltage.
	Open fuse F101 or F102 in power supply.	Replace fuse. If it blows again, check power supply.
	Transformer defective.	Check transformer output voltages.

TABLE 5-2. TROUBLESHOOTING (Cont.)

SYMPTOM	PROBABLE TROUBLE	CORRECTION
2. No illumination is observed on the screen of CRT. Pilot lamp lights.	Improper adjustment of BRILLIANCE or FOCUS controls. Improper adjustment or H POS or V POS controls.	Adjust these controls.
	Failure of B+ or CRT high-voltage supply.	Remove high-voltage lead to CRT and measure voltage. Remove the CRT high-voltage power supply from its cage and compare voltages measured between each terminal and the chassis with values shown in table 5-5.
	Defective CRT.	Replace CRT.
3. A dot or short line is observed on the screen but a horizontal baseline (horizontal sweep) is not obtained.	Faulty sweep stage.	Check tubes V801 to V804 and their tube socket resistances and voltages.
	E801 (NE-16) defective. DS801 (TS51) defective.	A P-P sawtooth of at least 50V should appear at pin 7, V803.
	Improper adjustment of LINE SIZE control.	Adjust this control. Use the procedure given in paragraph 5-16.
4. H POS control does not center the baseline trace.	Tube V804 or its circuitry is defective.	Check tube and the tube socket voltages and resistances. (Refer to table 5-5.)
5. With the SWEEP WIDTH control set at its maximum clockwise position, the vertical deflection (representing a signal or marker) does not appear as a peak, but rather as a shift in the baseline.	Defective sweep oscillator driver 160 MC IF amplifier.	Check tube V307 (200 KC-80 MC sweep).
		Check the tube socket voltages and resistances.
	SWEEP WIDTH control R861/R865 misadjusted or defective.	Rotate control to its maximum clockwise position. Check this control for open or shorts and replace if necessary.
	Inductor L347 defective.	Check and replace if necessary.
	Sweep oscillator stage is defective.	Check tubes V304, V305, V306, and V307 tubes and replace if necessary.
		Note: Replacement of any of these components requires the realignment of the corresponding IF strip.

TABLE 5-2. TROUBLESHOOTING (Cont.)

SYMPTOM	PROBABLE TROUBLE	CORRECTION
6. Inability to obtain full sweep frequency range.	Incorrect setting of SWEEP WIDTH limit potentiometer.	Readjust potentiometer R861/R865 (200KC-5 MC SWEEP) or R867/R871 (200KC-80 MC SWEEP). (Refer to paragraph 5-97.
	Defective variable inductor L342, oscillator tubes V307 or V804 phantastron V802 sweeper drive V803 or V307.	Check and replace if necessary.
7. The horizontal baseline is obtained, but is unstable in CAL and SYNC positions of the CAL-SYNC SEL switch.	Horizontal oscillator circuit not synchronized.	Adjust the SYNC AMPL control. Use the procedure given in paragraph 5-17.
	Faulty sweep stage.	Check tubes V801-V803 and E801, DS801, and the voltages and resistances for the tube sockets.
8. Horizontal baseline trace appears normal, but no vertical deflection signal or noise is observed.	Defective tube(s) in 6.5 MC or video amplifier stages. VIDEO FILTER switch shorted to ground.	Check tubes V605-V609 and V610-V612. Check to see that VIDEO FILTER switch-potentiometer has not twisted askew.
9. The tops of the pips on the screen of the CRT flatten off below full-scale deflection.	Tube V610 or its circuitry is defective.	Check tube and the tube socket voltages and resistances. (Refer to table 5-5.)
10. The V POS control does not line up the baseline with the frequency scale.	Tube V610 or its circuitry is defective.	Check tube and the tube socket voltages and resistances. (Refer to table 5-5.)
11. The amplitude of the signals on the screen is low with 0.2 of full scale of screen noise present.	Input signals of very low magnitude, or improper connections of the RF signals.	Check the input signals and the RF cables.
	Defective IF stage.	Check tubes in 160 MC, 75 MC, and 6.5 MC IF amplifiers. Check the tube socket voltages and resistances. (Refer to table 5-5.)
	Improper alignment of the indicator tuning circuits.	Realign the indicator. (Refer to paragraph 5-93.)
12. No marker pip but RF signal appears on screen.	Marker oscillator inoperative.	Check the marker oscillator. Check voltages at tube V401. Replace tube or defective components. (Refer to table 5-5.)

TABLE 5-2. TROUBLESHOOTING (Cont.)

SYMTPOM	PROBABLE TROUBLE	CORRECTION
13. With the SWEEP WIDTH control turned completely clockwise, the vertical deflection representing a 0 MC marker signal does not appear on the horizontal baseline at the zero line of the calibrated scale.	Improper adjustment of the coarse spectrum centering potentiometer R367 and CENTER FREQ. Capacitor C361.	Refer to paragraph 5-97.
14. The CENTER FREQ. control does not center signal when the scanning width is reduced.	Varistor RV301 is defective (200KC-80MC sweep).	Check and replace if necessary. Refer to table 5-5.
	Tube V347 or its circuitry defective.	Check and repair if necessary.
	SPECTRUM CENTERING potentiometer R367 (200KC-80MC sweep) misaligned or defective.	Realign this control. Use the procedure given in paragraph.
15. The frequency scanning is non-linear.	CF LIN adjustment R347 set incorrectly.	Adjust this control. Use procedure given in paragraph 5-97.
	Defective V307, L347 or circuitry. (200 KC-80 MC)	Check tube. Check tube socket voltages and resistances. (Refer to table 5-5.)
16. The screen of the CRT contains burned spots or "permanently" etched signal traces.	Defective CRT.	Set the CAL SYNC SEL switch to the CAL position. Turn SYNC AMPL control fully counterclockwise and adjust the SWEEP RATE control to give a fast random sweep across screen. Turn the BRILLIANCE, and FOCUS controls fully clockwise so that the screen is flooded. Leave the CRT this way for 5 or 6 hours. If the traces are not washed away at the end of this period, replace the CRT.
17. The screen of the CRT has high brilliance at all positions of the BRILLIANCE control.	CRT faulty.	Replace CRT, V114.
	Potentiometer R709 or capacitor C705 defective.	Check and replace if necessary.
18. The AMPLITUDE SCALE calibration is inaccurate.	Tubes V608 or V609 defective.	Check tube and the tube socket voltages and resistances. (Refer to table 5-5.)
	LOG 20 DB ADJUST and LOG ZERO ADJUST controls are misaligned.	Realign controls. Use the procedure given in paragraph 5-96.

TABLE 5-2. TROUBLESHOOTING (Cont.)

SYMPTOM	PROBABLE TROUBLE	CORRECTION
19. Resolution is unsatisfactory with the SWEEP WIDTH control set for a broad pip with IF BANDWIDTH control fully CW as evidenced by an asymmetrical pip, and/or appearance of a rejection slot.	Tube V604 or V606 is defective.	Check and replace if necessary. (Refer to paragraph 5-5.)
	Coils L611 or L613 or capacitor C627, C629, C637, or C642 misaligned or defective.	Realign coils and capacitors. Use the procedure given in paragraph 5-95.
	IF BANDWIDTH control R612 A/B or crystal CR601 or CR602 defective.	Check and replace if necessary. (Refer to paragraph 5-95.)
20. Low noise level. Signal appears when applied.	The IF GAIN control R637 is misadjusted or defective.	Set this control for $\frac{1}{2}$ or full scale noise on 200KC-80MC sweep.
	Low gain in analyzer.	(a) If marker amplitude is normal, examine 160 MC IF pre-amplifiers for defective tubes or components. (b) If marker amplitude is low, examine 160 MC IF, 75 MC IF, 6.5 MC IF, and video amplifiers for defective tubes or components.
21. Low noise level and no signal.	68.5 MC oscillator in IF-VIDEO chassis not operating. Defective wideband 160 MC IF amplifier, sweeper or sweeper drive circuits, 235 MC sweeper.	Check adjustment of L609. Check tube V608 and associated circuitry. Check for presence of normal marker amplitude.
		If the marker does not appear, the trouble is in the sweeper or the sweeper drive. Check for presence of a sawtooth at jack J302. If a sawtooth is present, check the 235 MC sweeper circuit. (Sawtooth voltage at pin 7, V803 should be a minimum of 50V P-P).
	Sweeper Drive.	If sawtooth is present, check the sweeper drive circuit, V307.
22. Varying amplitude (greater than ± 3 DB) of a signal that is tuned across the length of the horizontal baseline.	Defective tube in 160 MC IF amplifier. (Wideband or Preamplifier).	Check all tubes in amplifier. Check the socket voltages and resistances. CAUTION: Do not adjust slugs unless prepared to perform a complete realignment.

TABLE 5-2. TROUBLESHOOTING (Cont.)

SYMPTOM	PROBABLE TROUBLE	CORRECTION
23. (a) Low signal to noise ratio.	(a) Defective crystal mixer in RF tuner.	(a) Replace crystal.
(b) Signals do not track across entire range. (Bands 3 through 6)	(b) Incorrect klystron anode voltage or weak klystron.	(b) Readjust anode voltage. (Refer to paragraph 5-68.) Check klystron power supply. (Refer to paragraph 5-68.)
(c) Signals do not track across entire range: (Bands 1 & 2) (See Item 25)	(c) Tuning arm of triode oscillator loose or dirt on tracks.	(c) Clean triode tracks with approved solvent and cotton swab.
24. Noise normal but no signal.	(a) Defective crystal mixer in RF tuning unit.	(a) Replace crystal.
	(b) Crystal bias potentiometer misadjusted.	(b) Check crystal biasing circuit.
	(c) No local oscillator output.	(c) Set the INTERNAL CHECK switch to the XTAL CUR position. Needle should deflect at least minutely off zero. If there is no deflection, check local oscillator circuit. Replace defective tubes or other components.
	(d) RANGE switch defective. Relays K201, K202, K203, or K204 making poor or no contact.	(d) Continuity check circuitry.
	(e) Defective wideband oscillator.	(e) Refer to paragraph 5-97.
25. No RF sensitivity for portions of the tuning range (dead spots). (Bands 3 to 6)	Local oscillator klystron tube in RF tuning unit defective.	Check klystron RF power output by observing modes. Refer to paragraphs 5-98 through 5-105.
(See item 23)	Klystron tracking voltage off.	Check repeller voltage supply at jack J212 or J210 and refer to the repeller tracking procedure for the RF tuning unit. Refer to paragraph 5-106.
26. The indicator operates normally except that some vertical peaks are present along the baseline which do not move as the frequency of the external signal generator is varied.	Electrical interference, the frequency of which is synchronized with the sweep frequency of the indicator.	In many cases, the trouble may be traced to a nearby electrical appliance connected to the same power source as the Indicator, or the trouble may be in the power source. Corrective power filters may be used in the event that the interference is caused by appliances. If the power source is the cause and a motor generator set is being used, corrective filters should be used.

TABLE 5-2. TROUBLESHOOTING (Cont.)

SYMPTOM	PROBABLE TROUBLE	CORRECTION
27. (a) Signal "breakup". (Unusually high incidental FM on marker pip only). NOTE: 1. More than 1/10 CM in narrow sweep width using marker. 2. More than 25 kc on Wideband and Marker. No external signal.	Excessive ripple or oscillations in +250, -150, or -12 volt power supply.	With no external signal, use the MARKER as the applied signal and measure the incidental fm. Check +250, -150, or -12V power supplies for ripple. (Normal ripple approx. 5 mv, should not exceed 10 mv).
	Defective variable inductor L347, defective tubes V306, V307 in Wideband Amplifier.	Check tubes for microphonic tendencies. It may be necessary to realign sweep circuits when changing these tubes. Refer to paragraph 5-97.
(b) Signal "break-up" on Bands 3-6 unusually high incidental FM on external signal. Marker pip is normal.	Excessive ripple in klystron power supply.	Check klystron power supply. Refer to paragraph 5-68. Dirty contacts on all or any voltage relay.
NOTE: It is advisable to first determine that the breakup is not caused by the characteristics of the external signal. If possible, compare signals from several sources.	Kystron tube defective or microphonic.	Check operation of klystron tube. Refer to paragraph 5-98.
	Intermittant or poor contact in co-ax switches (S201 and S202).	Continuity check these switches.
28. Hum on baseline.	Low voltage power supply.	Check voltage and ripple of the +250, -150, and -12 volt outputs.
29. Overheating.	Dirty air filter.	Clean filter.
	Defective fan B101.	Replace fan.

5-31. SELF-CHECKING FEATURES. The analyzer contains a self-checking circuit designed to assist maintenance personnel in locating the general source of equipment troubles. When an input signal is applied and does not appear on the screen. Perform the following basic procedure:

a. Set the INTERNAL CHECK switch to the +250 position and note that the B+ power supply is functioning properly. The internal check meter should register about half scale. (Refer to table 5-3.)

b. Turn up the marker level control to obtain a marker pip on the screen. If a normal marker is obtained, the trouble is in the circuits before the 160 MC amplifier tube V301. If a normal marker cannot be obtained, the trouble is in the section beyond the marker input point (V301) or in the marker oscillator itself.

NOTE

If there is noise on the screen, the amplifiers are working properly indicating that the marker or swept oscillator circuits are defective. If there is no noise on the screen, one of the amplifiers is defective.

c. If a marker pip can be obtained on the screen, check for crystal bias and crystal current readings on all bands using the internal check meter. (Refer to table 5-3.) If no crystal bias voltage is obtained on any band, there is a defect in the crystal bias or current return circuit.

d. If crystal bias and current are obtained on some bands but not on all, the trouble may be a defective crystal or in the local oscillator. Tune across the dial and observe the crystal current reading over the entire band, since the tuning may have been set to a frequency of low local oscillator drive. Also check the current return circuit for that band.

e. The operation of the klystron oscillator can also be checked using the internal check meter. Set the INTERNAL CHECK switch to the KLYSTRON CUR position and note that the meter registers in the green. If there is no klystron current indication, set the INTERNAL CHECK switch to the ANODE V position. The meter should register approximately half scale.

f. If the anode voltage is normal and there is no klystron current, check the associated wiring and connectors. If these are in order, the klystron is defective and must be replaced. If the anode voltage is low, check the klystron power supply and associated switches.

g. If the klystron is operating normally, check the signal leads between the klystron output probe and the input connection to the mixer. Also examine the probe itself to check that the solder connections on the 50-ohm klystron resistor have not broken loose. Do not remove the probe from the klystron cavity; to make this measurement, merely disconnect it from the relay. If the probe is removed, a complete realignment of the klystron is required. Check the coaxial switching.

NOTE

Bands 3 through 6 use either the fundamental or harmonic output of the klystron. Accordingly, if any of these bands is functioning properly, the trouble is not likely to be in the klystron.

TABLE 5-3. INTERNAL CHECK METER INDICATIONS

INTERNAL CHECK SWITCH POSITION	METER MEASURES	REQUIRED METER INDICATION
XTAL CUR (Note 1)	Rectified signal current at crystal.	Any on-scale reading.
XTAL BIAS	DC crystal bias current at operating mixer.	Any on-scale reading.
KLYSTRON CUR	Klystron cathode current.	From .4 to .7 ((In green KLYSTRON area) (Note 2).
ANODE V	Klystron anode voltage.	Mid-scale (Green N) (Note 2).
+250	Equipment 250 volt B+ supply.	Mid-scale (Green N).
LINE V	External line voltage.	Any scale reading (105-125 volts).

NOTES:

1. The XTAL CUR position is a momentary contact. The INTERNAL CHECK switch is spring-loaded and, upon release, will return to the XTAL BIAS position.

2. Meter reads only when the RANGE switch is in the 3-12 KMC or 12-43 KMC positions.

5-32. GAIN MEASUREMENTS.

5-33. The stage gain measurements listed in Table 5-4 have been provided to assist maintenance personnel in localizing a trouble under dynamic conditions. The measurements listed were made by injecting the appropriate signal into each stage at the indicated point and noting the signal level required to cause full scale deflection of the CRT trace. The measurements listed are typical for a normally operating unit.

5-34. Circuit failures can be detected by duplicating the above procedures and comparing the signal levels required to obtain full scale baseline deflection with the corresponding levels listed in Table 5-4. By beginning with the stage nearest the CRT and checking in the reverse direction, the operator can quickly localize most equipment troubles. These troubles can then be isolated using the voltage and resistance measurements listed in Table 5-5.

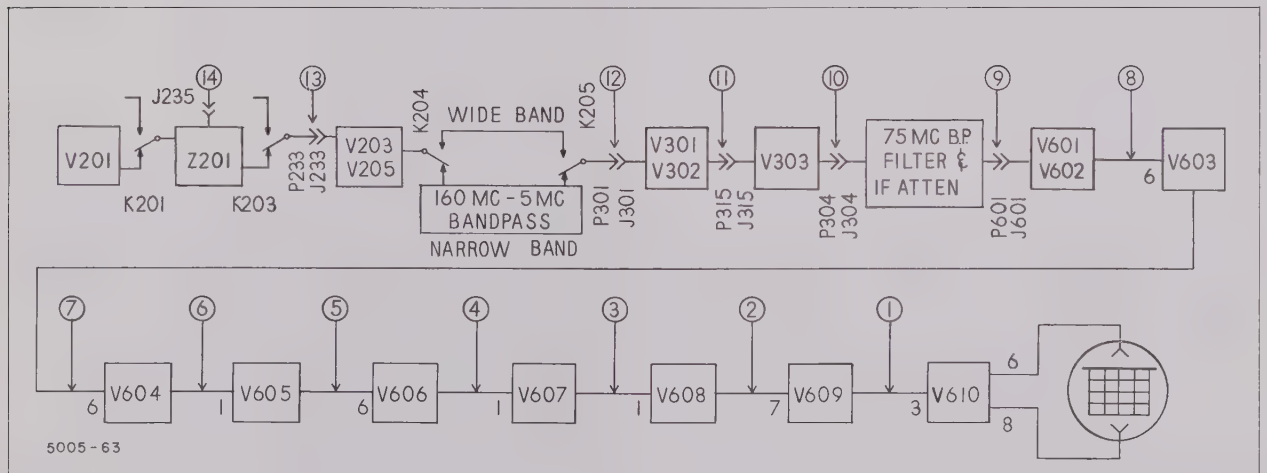
5-35. All measurements were taken under normal operating conditions using extension cables and removing chassis shields when required. The test equipment required to perform these measurements is listed in the following tabulation:

Nomenclature	Manufacturer	Model
Signal Generator	The Singer Company, Metrics Division	SG-8
Signal Generator	The Singer Company, Metrics Division	SG-9
Oscillator	Hewlett-Packard (or equivalent)	200 CD
Oscilloscope	Techtronix (or equivalent)	545
Power Supply	Kepco	ABC 30-0-3M

5-36. The operating controls should be set to the positions listed in the following tabulation unless otherwise indicated:

CONTROL	POSITION
SWEEP RATE	Synchronized at 30 cps
IF BANDWIDTH	Fully clockwise
SWEEP WIDTH	Fully clockwise

TABLE 5-4. STAGE GAIN MEASUREMENTS



SIGNAL INJECTION POINT	STAGE	SIGNAL INPUT FREQ.	SIGNAL INPUT LEVEL	STAGE GAIN	NOTES
1 — Pin 3, V610	Vert. Amp (V610)	-	-4 VDC	(Note 6)	5,6
2 — Pin 7, V609	Detector (V609)	6.5MC	3VAC or +230DBM	-	1,5
3 — Pin 1, V608	6.5 MC Amp. (V608)	6.5MC	-15 DBM	38DB	1,5

TABLE 5-4. STAGE GAIN MEASUREMENTS (Cont.)

SIGNAL INJECTION POINT	STAGE	SIGNAL INPUT FREQ.	SIGNAL INPUT LEVEL	STAGE GAIN	NOTES
4 — Pin 1, V607	6.5 MC Amp. (V607)	6.5MC	LOG: -14DBM	-	1,2,5
— Pin 1, V607	6.5 MC Amp. (V607)	6.5MC	LIN: -37DBM	22DB	1,2,5
— Pin 1, V607	6.5 MC Amp. (V607)	6.5MC	PWR: -33DBM	-	1,2,5
5 — Pin 6, V606	Cathode Foll. (V606)	6.5MC	-27DBM	-10DB	1,5
6 — Pin 1, V605	6.5MC Amp. (V605)	6.5MC	-50DBM	23DB	1,5
7 — Pin 6, V604	Cathode Foll. (V604)	6.5MC	-39DBM	-11DB	1,5
8 — Pin 6, V603	Mixer ($\frac{1}{2}$ V603)	75MC	-47DBM	8DB	1,5
9 — J601	75 MC Amp. (V601, V602)	75MC	-104DBM	57DB	3
10 — J304	75 MC BP Filter & IF Atten.	75MC	-100DBM	-	3
11 — J315	Mixer (V303)	160MC	-87DBM	-13DB	3,4
12 — J301	160 MC Amp. (V301,V302)	160MC	-99DBM	12DB	3,4
13 — J233	160 MC Preamp. (V203, V205)	160MC	-110DBM	15DB	3,4,8
J233	160 MC Preamp. (V203, V205)	160MC	-114DBM	15DB	3,4,7
14 — INPUT 10 MC-12 KMC Recpt.	Coaxial Mixer (Z201)	160MC	-102DBM	-	4,9

NOTES:

1. To avoid loading the circuit, inject the signal through a pad of at least 6 db and terminated in a 50 ohm resistor. Use a .01 mfd. blocking capacitor to isolate the signal generator.

2. Signal sensitivity is listed for each position of the AMPLITUDE SCALE switch. The gain of stage V607 refers only to the LIN position.

3. Disconnect the mating plug. Insert 10 DB Pad in series with signals input.

4. Disable the sweep by disconnecting plug P307.

5. Disconnect plug P601.

6. Refer to figures 5-7 through 5-9.

7. Set the analyzer to the wideband mode by positioning the dial pointer to any frequency above 100 MC.

8. Set the analyzer to the narrow band mode by positioning the dial pointer to 90 MC.

9. Set the dial pointer to 700 MC. The indication on the CRT is the result of a non-converted signal.

CONTROL	POSITION
VIDEO FILTER	Fully counterclockwise
AMPLITUDE SCALE	LIN
MARKER FREQUENCY	0
MARKER LEVEL	OFF
IF ATTEN 20 DB	Fully counterclockwise
IF ATTENTUATOR (Switches)	Down
SPECTRUM CENTERING	Center travel
BRILLIANCE	Desired trace brightness
INTENSIFIER	Fully counterclockwise
FOCUS	Sharp trace
ASTIG	Uniform focus
CAL SYNC SEL	LINE
SYNC AMPL	Synchronized sweep
RANGE	10 MC-3KMC
INTERNAL CHECK	XTAL BIAS
TUNING	Above 100MC unless otherwise noted.

5-37. When injecting 160 MC, 75 MC, or 6.5 MC signals, adjust the signal generator tuning control to place the signal of the bandbass under test to provide maximum input amplitude. At low level signal stages, considerable noise will be displayed on the CRT trace and it will be necessary to average the readings to obtain the proper measurement. The indicated gains are approximate stage gains (i.e. tube gain plus the effect of associated components). All signal levels are RMS measurements unless otherwise noted.

5-38. WAVESHAPE EXAMINATION.

5-39. As an aid to maintenance personnel, typical waveforms taken from various circuits are shown in figures 5-7 through 5-9. These measurements are made under normal operating conditions using tube adapters and removing shields when necessary. Use a 10:1 high impedance oscilloscope probe to minimize circuit loading. Set the operating controls to the positions indicated in the following tabulation.

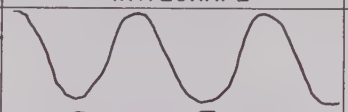
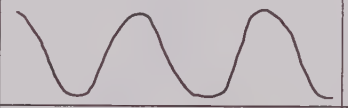
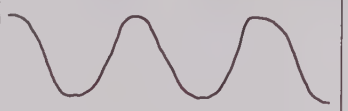
CONTROL	POSITION
SWEEP RATE	Synchronized at 60 cps
GAL SYNC SEL	CAL
SYNC AMPL	Minimum level for stationary trace
SWEEP WIDTH	Fully clockwise
RANGE	10 MC — 3 KMC
TUNING	Above 100 MC (wideband mode)
MARKER LEVEL	OFF

All other controls as required for sharp trace.

5-40. VOLTAGE AND RESISTANCE MEASUREMENTS. The voltage and resistance measurements listed in table 5-5 are designed to assist maintenance personnel in locating defective components after they have been localized by testing procedures. The measurements listed were taken under normal operating conditions using extension cables and removing chassis shields when necessary. Unless otherwise specified by a NOTE in the table, the operating controls were set to the positions listed in the following tabulation:

CONTROL	POSITION
SWEEP RATE	Synchronized at 30 cps
IF BANDWIDTH	Fully clockwise
SWEEP WIDTH	Fully clockwise
VIDEO FILTER	Fully counterclockwise
AMPLITUDE SCALE	LIN
MARKER FREQUENCY	0 Megacycles
MARKER LEVEL	Fully clockwise
IF ATTEN 20 DB	Fully clockwise
IF ATTENTUATOR	Adjusted for approximately full scale signal pip
SPECTRUM CENTERING	Pip centered on screen

VIDEO AMPLIFIER

STAGE	WAVESHAPE	VOLTAGE P-P	GAIN	COMMENTS
VERT. AMP., 1/2-SD504				REMOVE DETECTOR V609. CHECK THE OPERATION OF VARIOUS STAGES BY INJECTING A 1,000 CYCLE SIGNAL AT 1 VOLT P-P TO PIN 3 OF V610.
INPUT V610 PIN 3		1 V.	—	
OUTPUT V610 PIN 5		27 V.	27	
OUTPUT V610 PIN 6		22 V.	22	
INTENSIFIER, 1/2-12AU7				
INPUT V611 PIN 7		20 V.	—	
OUTPUT V611 PIN 8		22 V.	1.1	
BLANKER, 6CB6				
INPUT V612 PIN 1		3.8 V.	—	
OUTPUT V612 PIN 5		250 V.	66	

5005-64

Figure 5-7. Waveforms — IF — Video Amplifier

5-41. The other operating controls were set to their normal positions for a sharp, well-defined signal. Line voltage was set to 115 VAC. All measurements were made with respect to ground using a VTVM unless otherwise specified by a NOTE in the table.

5-42. REMOVAL AND REPLACEMENT.

5-43. Removal procedures for analyzer components requiring more than obvious removal techniques are described in paragraphs 5-44 through 5-54. (See also figures 5-11 through 5-23.) Replace components in the reverse order.

5-44. INDICATOR UNIT AND TUNING HEAD REMOVAL. To remove the Indicator Unit and the Tuning Head from the cabinet, perform the following steps:

a. Unscrew the 10 knurled captive screws on the front panel and slide the Tuning Head out until it clears the cabinet.

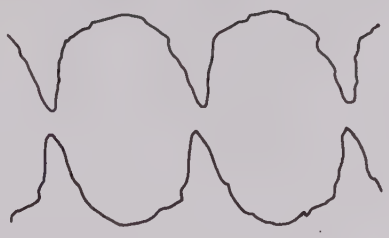
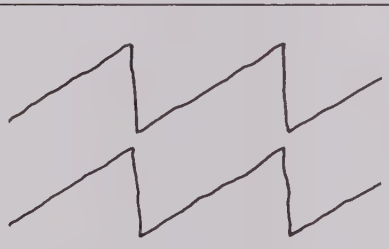
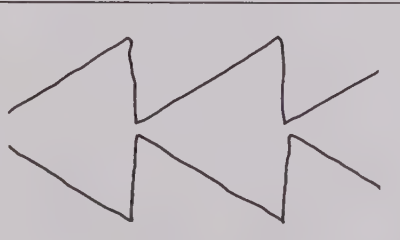
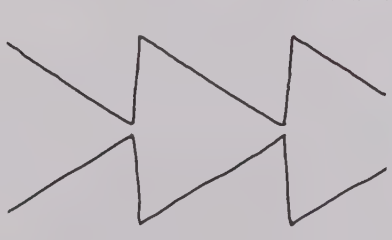
b. Disconnect the interconnecting cables running to the Indicator Unit and the power cable plug P102 at the inside rear of the cabinet.

NOTE

Proper cable connection is readily made since corresponding color code dots are applied to all coax plugs and jacks. A list of the equipment cables is provided in table 5-6.

c. Remove the 10 front panel screws and carefully slide the Indicator Unit forward until its slide clears the guide track.

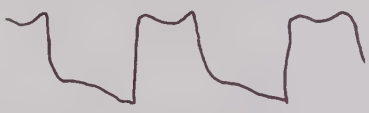
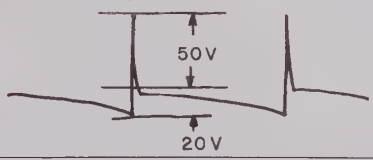
HORIZONTAL SWEEP GENERATOR AND AMPLIFIER

STAGE	WAVE SHAPE	VOLTAGE P-P	COMMENTS
SYNC AMP., 1/2-12AT7			WAVESHAPE REPRESENTS DISTORTED SINE WAVE. CONFIGURATION WILL CHANGE WITH POSITION OF SYNC AMPL CONTROL.
INPUT V801 PIN 2		1.2 V.	
OUTPUT V801 PIN 1		42 V.	
SYNC AMP., 1/2-12AT7			
INPUT V801 PIN 7		42 V.	
OUTPUT V801 PIN 6		225 V.	
SAWTOOTH GEN., 6CB1A			
INPUT V802 PIN 1		1.6 V.	
OUTPUT V802 PIN 5		75 V.	
CATHODE FOL., 6AB4			
INPUT V803 PIN 6		75 V.	
OUTPUT V803 PIN 7		75 V.	
HORIZ. AMP., 1/2-12AU7			SET LINE SIZE CONTROL IN NORMAL POSITION AND ADJUST H POS CONTROL FOR MAXIMUM UNDISTORTED OUTPUT.
INPUT V804 PIN 2		14V.	
OUTPUT V804 PIN 1		145 V.	
HORIZ. AMP., 1/2-12AU7			
INPUT V804 PIN 7		14 V.	
OUTPUT V804 PIN 6		118 V.	

5005-65

Figure 5-8. Waveforms — Horizontal Sweep Generator and Amplifier

AGC AMPLIFIERS AND SAWTOOTH DRIVER

STAGE	WAVE SHAPE	VOLTAGE P-P	COMMENTS
AGC AMP., 1/2-12AX7			WAVESHAPE SHOWN IS TYPICAL BUT CONFIGURATION MAY VARY IN NORMALLY OPERATING SETS. PEAK-TO-PEAK AMPLITUDE IS THE IMPORTANT VARIABLE IN THESE SIGNALS.
INPUT V304 PIN 2		18 MV.	
OUTPUT V304 PIN 1		600 MV.	
AGC AMP., 1/2-12AX7			
INPUT V304 PIN 7		410 MV.	
OUTPUT V304 PIN 6		32 V.	
AGC AMP., 6AQ5A			
INPUT V305 PINS 1,7		32 V.	
OUTPUT V305 PIN 2		29 V.	DISCONNECT PLUG P315. THE LEADING EDGE OF THE OUTPUT WAVESHAPE SHOULD SHOW A SHARP RISE-TIME, WHILE THE TRAILING EDGE SHOULD BE LINEAR WITH A MINIMUM OF BREAKUP.
SAWTOOTH DRIVER-6AQ5A			
GRID V306 PINS 1,7		50 V.	
CATHODE V306 PIN 2		28 V.	
SCREEN V306 PIN 6		23 V.	
PLATE V306 PIN 5		70 V.	

5005-66

Figure 5-9. Waveforms — AGC Amplifiers and Sawtooth Driver

TABLE 5-5. VOLTAGE AND RESISTANCE MEASUREMENTS

POWER SUPPLY VOLTAGE MEASUREMENTS

Ref. Desig.	Tube Type	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7	Pin 8	Pin 9	Notes
V101	6550	245	255	470	475	245	250	255	255	N/C	1
V102	6550	245	255	470	475	245	250	255	255	N/C	1
V103	6550	245	255	470	475	245	250	255	255	N/C	1
V104	12AX7	250	133	136	0.35	0.35	245	132	136	0.35	1
V105	OG3	85	0	N/C	0	85	N/C	0	N/C	N/C	1
V106	12AX7	134	50	51	0.35	0.35	134	49	51	0.35	1
V107	OA2	0	148	N/C	148	0	N/C	148	N/C	N/C	1
V108	6550	N/C	0	305	81	-3.4	83	6.3 VAC	0.55	N/C	1
V109	6AH6	-342	-350	-350	-350	-3.3	-208	-350	N/C	N/C	1
V110	OD3	0	-945	N/C	N/C	-800	0	N/C	N/C	N/C	1
V111	OD3	N/C	-800	N/C	N/C	-660	N/C	N/C	N/C	N/C	1
V112	OD3	N/C	-660	N/C	N/C	-490	0.5	N/C	N/C	N/C	1
V113	OD3	N/C	-490	N/C	N/C	-350	N/C	N/C	N/C	N/C	1
V114	6BQ5	N/C	-43.5	0	0	6.3 VAC	N/C	250	N/C	143	1

POWER SUPPLY RESISTANCE MEASUREMENTS

Ref. Desig.	Tube Type	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7	Pin 8	Pin 9	Notes
V101	6550	5 Meg	750	3 Meg	2.5 Meg	5 Meg	700	750	750	N/C	1
V102	6550	5 Meg	750	3 Meg	2.5 Meg	5 Meg	700	750	750	N/C	1
V103	6550	5 Meg	750	3 Meg	2.5 Meg	5 Meg	700	750	750	N/C	1
V104	12AX7	700	400 K	240 K	Inf.	Inf.	3.7 Meg	370 K	240 K	Inf.	1
V105	OG3	19 K	0	16 K	0	19 K	N/C	0	N/C	N/C	1
V106	12AX7	400 K	134 K (Note 2)	82 K	Inf.	Inf.	400 K	47 K	82 K	Inf.	1
V107	OA2	0	6.8 K	N/C	6.8 K	0	N/C	6.8 K	N/C	N/C	1
V108	66550	N/C	0	1.1 Meg	40 K	2.2 Meg	37 K	0	9	N/C	1
V109	6AH6	170 K (Note 2)	1.2 K	1.2 K	1.2 K	2.2 Meg	9 K	1.2 K	N/C	N/C	1
V110	OD3	20 K	100 K	N/C	N/C	160 K	68 K	N/C	N/C	N/C	1
V111	OD3	N/C	160 K	N/C	N/C	160 K	N/C	N/C	N/C	N/C	1
V112	OD3	N/C	160 K	N/C	N/C	100 K	9	N/C	N/C	N/C	1
V113	OD3	N/C	100 K	N/C	N/C	1.2 K	N/C	N/C	N/C	N/C	1
V114	6BQ5	N/C	100 K	0	0	0	N/C	27 K	N/C	37 K	1

TABLE 5-5. VOLTAGE AND RESISTANCE MEASUREMENTS ((Cont.)

TUNING HEAD VOLTAGE MEASUREMENTS											
Ref. Desig.	Tube Type	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7	Pin 8	Pin 9	Notes
V201	6AF4A	45-85 (Note 5)	-0.1 to -3.5 (Note 5)	5.6	0	0	-0.1 to -3.5 (Note 3)	45-85 (Note 3)	N/C	N/C	3,4
V203	5842	140	N/C	5.7 VAC	0	0	1.7	0	0	N/C	3,4
V205	5842	120	N/C	5.7 VAC	0	0	1.6	0	0	N/C	3,4
V207	6BL6	-350	-344 (Note 9)	-350	-350	N/C	N/C	N/C	N/C	N/C	6,7,8
TUNING HEAD RESISTANCE MEASUREMENTS											
Ref. Desig.	Tube Type	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7	Pin 8	Pin 9	Notes
V201	6AF4A	15 K	7.5 K	0.1	0	0	7.5K	1.7K	N/C	N/C	3,4
V203	5842	6 K	N/C	0.5	0	0	63	0	0	N/C	3,4
V205	5842	6 K	N/C	0.5	0	0	63	0	0	N/C	3,4
V207	6BL6	33 K	33 K (Note 9)	33 K	33 K	N/C	N/C	N/C	N/C	N/C	6,10
WIDEBAND AMPLIFIER VOLTAGE MEASUREMENTS											
Ref. Desig.	Tube Type	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7	Pin 8	Pin 9	Notes
V301	5842	147	N/C	5.9 VAC	0	0	1.1	0	0	0	3
V302	5842	147	N/C	5.9 VAC	0	0	1.35	0	0	0	3
V303	6AF4A	22	-1.9	5.9 VAC	-11	0.08	-1.9	22	N/C	N/C	3
V304	12AX7	150	-2	-0.53	0	0	45	-0.8	0	5.9 VAC	3,11
V304	12AX7	150	-2.1	0.55	0	0	33	-0.56	0	5.9 VAC	3,4, 12
V305	6AQ5	41	57	5.9 VAC	0	250	250	41	N/C	N/C	3,11
V305	6AQ5	42	49	5.9 VAC	0	250	250	42	N/C	N/C	3,4, 12
V306	6AQ5	16 VAC 0.05 VDC (Note 13)	16	-5.9	0	39 VAC 250 VAC (Note 13)	197	16 VAC 0.05 VDC (Note 13)	N/C	N/C	3,11
V306	6AQ5	1.1 VAC 0 VDC (Note 13)	16	-5.9	0	4.1 VAC 250 VDC (Note 13)	197	1.1 VAC 0 VDC (Note 13)	N/C	N/C	3,4, 12

TABLE 5-5. VOLTAGE AND RESISTANCE MEASUREMENTS (Cont.)

WIDEBAND AMPLIFIER VOLTAGE MEASUREMENTS (Cont.)

Ref. Desig.	Tube Type	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7	Pin 8	Pin 9	Notes
V307	6AF4A	16 VAC 56 VDC (Note 13)	3 VAC -3 2VDC (Note 13)	-5.9	0	-12	3 VAC -3.2VDC (Note 13)	16 VAC 56 VDC (Note 13)	N/C	N/C	3,11
V307	6AF4A	5.7 VAC 48 VDC (Note 13)	2.5 VAC 2.8 VDC (Note 13)	-5.9	0	-12	2.5 VAC -3.2 VDC (Note 13)	5.7 VAC 48VDC (Note 13)	N/C	N/C	3,4, 12

WIDEBAND AMPLIFIER RESISTANCE MEASUREMENTS

Ref. Desig.	Tube Type	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7	Pin 8	Pin 9	Notes
V301	5842	7 K	N/C	0.2	0	0	35	0	0	0	3
V302	5842	8 K	N/C	0.2	0	0	60	0	0	0	3
V303	6AF4A	75 K	450 K	3.5	5.5	26	470 K	75 K	N/C	N/C	3
V304	12AX7	110 K	560 K	1 K	0	0	1 Meg	800 K	0	0.1	3,11
V304	12AX7	110 K	560 K	1 K	0	0	1 Meg	800 K	0	0.1	3,4,12
V305	6AQ5	2 Meg	60 Meg	0.1	0	6 K	6 K	2 Meg	N/C	N/C	3,4,11
V305	6AQ5	2 Meg	60 Meg	0.1	0	6 K	66 K	2 Meg	N/C	N/C	3,4,12
V306	6AQ5	1 Meg	2 K	3	0	6.5 K	11 K	1 Meg	N/C	N/C	3,11
V306	6AQ5	1 Meg	2 K	3	0	6.5 K	11 K	1 Meg	N/C	N/C	3,4,12
V307	6AF4A	Inf.	51 K	3	0	6	51 K	Inf.	N/C	N/C	3,11
V307	6AF4A	Inf.	51 K	3	0	6	51 K	Inf.	N/C	N/C	3,4,12

IF-VIDEO AMPLIFIER VOLTAGE MEASUREMENTS

Ref. Desig.	Tube Type	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7	Pin 8	Pin 9	Notes
V601	6688	14	10	14	5.6 VAC	0	0	240	0	235	3
V602	6688	14	10	14	5.6 VAC	0	0	240	0	235	3
V603	6J6	135	58	0	5.6 VAC	-7	0	0	N/C	N/C	3
V604	6AB4	245	0	0	5.6 VAC	0	0	0	N/C	N/C	3
V605	6BJ6	0	0	5.7 VAC	0	250	110	0	N/C	N/C	3
V606	6AB4	242	0	5.8 VAC	0	0	0	2.3	N/C	N/C	3
V607	6BJ6	0	0	5.8 VAC	0	248	108	0	N/C	N/C	3
V608	6AH6	0	0	0	5.8 VAC	240	185	0	N/C	N/C	3
V609	6AL5	0.2	0	0	5.9 VAC	0	0	0	N/C	N/C	3
V610	SD504	0	0	0	0	0	180	155	100	6.0 VAC	3
611	12AU7	160	0	0	0	0	250	140	160	6.0 VAC	3
612	6CB6	-2.7	0	6.0 VAC	0	140	72	0	N/C	N/C	3

TABLE 5-5. VOLTAGE AND RESISTANCE MEASUREMENTS (Cont.)

IF-VIDEO AMPLIFIER RESISTANCE MEASUREMENTS

Ref. Desig.	Tube Type	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7	Pin 8	Pin 9	Notes
V601	6688	1.5 K	19 K	1.5 K	0.1	0	Inf.	12 K	0	24 K	3
V602	6688	1.1 K	19 K	1.1 K	0.1	0	Inf.	12 K	0	22 K	3
V603	6J6	18 K	56	0	0.1	22 K	20 K	68	N/C	N/C	3
V604	6AB4	9 K	0	0	0.1	0	1 Meg	340	N/C	N/C	3
V605	6BJ6	0.7	150 (Note 2)	0.1	0	7.6 K	70 K	0	N/C	N/C	3
V606	6AB4	9 K	0	0.1	0	0	1 Meg	340	N/C	N/C	3
V607	6BJ6	0.7	180	0.1	0	7.6 K	70 K	0	N/C	N/C	3
V608	6AH6	8.7 K	170	0	0.1	9 K	16 K	170	N/C	N/C	3
V609	6AL5	100 K (Note 2)	100 K (Note 2)	0	0.1	0.8	0	0.8	N/C	N/C	3
V610	SD50A	7 K	100	170 K	0	0	18 K	18 K	16 K	0.1	3
V611	12AU7	40 K	35 K	2.2 K (Note 2)	0	0	8 K	150 K	50 K	0.1	3
V612	6CB6	500 K	0	0.1	0	68 K	8 K	0	N/C	N/C	3

CATHODE RAY TUBE VOLTAGE MEASUREMENTS

Reg. Desig.	Tube Type	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7	Pin 8	Pin 9	Notes
V701	5ADP1	-2300	-2300	-2250	N/C	-1400	N/C	140	140	160	3,7

Pin 10	Pin 11	Pin 12	Pin 13	Pin 14	Notes
160	110	N/C	N/C	-2300	3,7

CATHODE RAY TUBE RESISTANCE MEASUREMENTS

Ref. Desig.	Tube Type	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7	Pin 8	Pin 9	Notes
V701	5ADP1	17 Meg	17 Meg	18 Meg	N/C	11 Meg (Note 4)	N/C	210 K	240 K	36 K	3

Pin 10	Pin 11	Pin 12	Pin 13	Pin 14	Notes
18 K	18 K	N/C	N/C	17 Meg	3

TABLE 5-5. VOLTAGE AND RESISTANCE MEASUREMENTS (Cont.)

HORIZONTAL CHASSIS VOLTAGE MEASUREMENTS

Ref. Desig.	Tube Type	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7	Pin 8	Pin 9	Notes
V801	12AT7	27	0.3	0.21	5.9 VAC	5.9 VAC	150	-12	1.3	0	3
V802	6CB6	0.06 VAC -0.95 VDC (Note 13)	0	0	5.9 VAC	22 VAC 150 VDC (Note 13)	22	0	N/C	N/C	3
V803	6AB4	250	N/C	5.9 VAC	0	0	22 VAC 148 VDC (Note 13)	13 VAC 150 VDC (Note 13)	N/C	N/C	3
V804	12AU7	47VAC 142VDC (Note 13)	4 VAC 0 VDC (Note 13)	9	5.9 VAC	5.9 VAC	38 VAC 138VDC (Note 13)	4.2 VAC 12.5VDC (Note 13)	20	0	3

HORIZONTAL CHASSIS RESISTANCE MEASUREMENTS

Ref. Desig.	Tube Type	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7	Pin 8	Pin 9	Notes
V801	12AT7	1 Meg	140 K	1 K	0	0	2.2 Meg	1.1 Meg	3 K	0	3
V802	6CB6	160 K (Note 2)	0	0	0	500 K	10 K	0	N/C	N/C	3
V803	6AB4	7.5 K	N/C	0	0	Inf.	500 K	33 K	N/C	N/C	3
V804	12AU7	200 K	1.6 Meg (Note 2)	2.5 K (Note 2)	0	0	230 K	160 K	5.1 K	0	3

NOTES:

1. During power supply measurements, disconnect plugs P201 (Tuning Head), P309 (wideband chassis), and P602 (IF-video chassis) and the B+ lead to FL 402 (marker chassis). Remove tubes V801, V802, V803, and V804 and connect the dummy load shown in figure 5-10.
2. Varies with control settings.
3. Tuning Head disconnected. (Disconnect plugs P201 and P255 and the MARKER MOD and EXT SYNC cables.)
4. Set the RANGE switch to the 10MC-3KMC position.
5. Indicates the minimum and maximum voltages as oscillator tube V201 is tuned across the band.
6. Tuning Head connected. (Connect plugs P201 and P255 and the MARKER MOD and EXT SYNC cables.)
7. Use an ungrounded multimeter rated at 20,000 ohms per volt with a minimum range of 3000 VAC and 5000 VDC.
8. Plate cap voltage is -400 to -860 VDC, varying with control settings.
9. Set the RANGE switch to the 3-12 KMC position.
10. Plate cap resistance is approximately 500 K.
11. Set the TUNING control above 100 MC (wideband mode).
12. Set the TUNING control below 100 MC (narrow band mode).
13. In measuring this sawtooth voltage, two values are given. The upper voltage is the average value indicated by the VTVM when the SWEEP RATE control is set for 30 cps. The lower voltage is the average DC level.

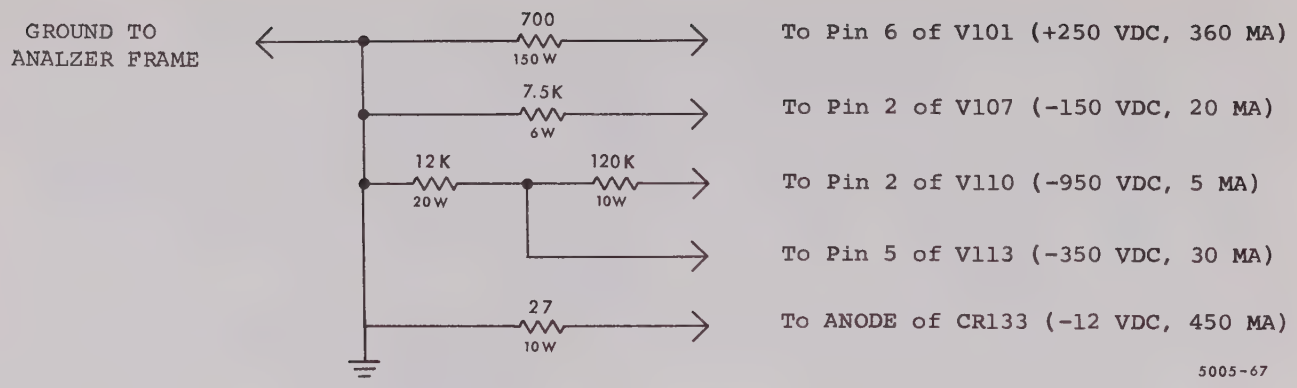


Figure 5-10. Dummy Load

d. Rest the Indicator Unit transformers on the center partition and clear all of the cables. Remove the Indicator Unit from the cabinet.

NOTE

When operating the analyzer while removed from the cabinet, it will be necessary to use a "cheater" cord to provide AC power. Connect a 3 wire jumper from a suitable external power source to pins 1 and 2 of plug P102 on the Indicator Unit and to a good chassis ground. Fuse both power leads with 5 amp fuses.

5-45. INDICATOR UNIT AND TUNING HEAD REPLACEMENT. To replace the Indicator Unit and the Tuning Head in the cabinet, perform the following steps:

a. Rest the Indicator Unit transformers on the center partition shelf of the cabinet. Do not insert the slide into the guide.

b. Feed in all of the cables connected to the Indicator Unit keeping the center partition shelf clear.

c. Insert the slide into the guide and slide the Indicator Unit into the cabinet.

d. Dress the cables and connect plug P102 to receptacle J102 at the inside rear of the cabinet. Check that the pins are properly matched.

e. Connect the interconnecting cabling to the Tuning Head. Observe the color coding on the signal cables.

f. Slide the Tuning Head into the cabinet and tighten the front panel screws on both units.

5-46. HORIZONTAL CHASSIS REMOVAL. To expose the rear of the horizontal chassis for voltage measurements, remove the screw (9, figure 5-12) at the right side of the chassis and swing out the chassis on its hinge.

5-47. IF-VIDEO CHASSIS REMOVAL. To remove the IF-VIDEO chassis from the Indicator Unit, perform the following steps:

a. Remove the INTENSIFIER, VIDEO FILTER, AMPLITUDE SCALE, and IF BANDWIDTH knobs from their shafts.

b. Remove the retaining nuts from the INTENSIFIER and VIDEO FILTER control shafts and push these shafts through their front panel holes.

c. Remove the screw at upper right, rear of the video chassis.

d. Remove the screw (9, figure 5-12) and swing out the horizontal chassis.

e. Disconnect cable plugs at receptacles J601 and J602 (8 and 31, figure 5-13).

f. Slide the video chassis back, away from the front panel, and remove from the analyzer.

5-48. TRIODE OSCILLATOR REMOVAL. To remove the triode oscillator from the Tuning Unit, perform the following steps:

a. Unsolder the wires at the feedthrough capacitors C204 and C202 (3 and 4, figure 5-20).

TABLE 5-6. INTERCONNECTING CABLES

ITEM	REF. DESIG.	PART NO.	RG TYPE	LENGTH	FROM		TO	
					CIRCUIT	CONN.	CIRCUIT	CONN.
1	---	556161-002 (Notes 1 & 2)	195/U	5"	MARKER FILTER	J419	WIDEBAND AMPL.	J303
2	W303	556161-008 (Notes 1 & 2)	195/U	12½"	MARKER LEVEL POT.	J403	MARKER FILTER	J417
3	W307	556161-008 (Note 2)	195/U	12½"	75 MC MIXER	J305	75 MC FILTER	J304
4	W301	556161-007 (Note 2)	195/U	6"	WIDEBAND AMPL.	J313	75 MC MIXER	J315
5	W210	556161-314	195/U	50"	WIDEBAND AMPL.	J301	PREAMP (T.H.)	J255
6	W302	556161-006	195/U	61"	MARKER	J401	MARKER MOD.	J259
7	---	556161-020	195/U	65"	EXT. SYNC.	J261	CAL.SYNC.SEL. SW.	S801
8	W212	556161-315	195/U	10"	RELAY K204 N/O	J245	160 MC FILTER	J247
9	W211	556161-309	195/U	8"	RELAY K204 (N/C)	J243	RELAY K205 (N/C)	J251
10	W226	556161-315	195/U	10"	RELAY K205 (N/O)	J253	160 MC FILTER	J249
11	W205	556161-316	195/U	6½"	RELAY K204 (O/P)	J241	PREAMP OUTPUT	J237
12	W202	556161-304	188/U	11"	RELAY K203 (N/C)	J225	LF MIXER Z201	J227
13	W204	556161-304	188/U	11"	RELAY K203 (O/P)	J223	PREAMP INPUT	J229
14	W203	556161-028	188/U	32"	RELAY K203 (N/O)	J221	HF MIXER Z202	J219
15	---	556161-298	55/U	9"	RELAY K201 (N/C)	J203	3 DB PAD AT203	---
16	---	556161-264	55/U	20"	TRIODE OSC. OUTPUT	P202	3 DB PAD AT203	---
17	W201	556161-027	188/U	24"	RELAY K202 (N/O)	J215	HF MIXER Z202	J217
18	W209	556161-024	195/U	26"	EXT. SYNC. JACK (FRONT)	J265	EXT. SYNC. JACK (REAR)	P261
19	W209	556161-024	195/U	65"	MARKER MOD. JACK	J263	MARKER MOD. JACK (REAR)	P259

TABLE 5-6. INTERCONNECTING CABLES (Cont.)

ITEM	REF. DESIG.	PART NO.	RG TYPE	LENGTH	FROM		TO	
					CIRCUIT	CONN.	CIRCUIT	CONN.
20	---	556161-021	195/U	13"	SAWTOOTH INPUT	J307	RELAY K801 (O/P)	---
21	---	556161-433	55/U	5"	ATT. OUTPUT	--	BARREL ASSY.	---
22	---	556161-212	--	72"	EXT. PWR.	--	EXT. PWR. RECPT.	J101
23	---	556161-388	55/U	14"	AT202	--	---	---
24	W309	556161-016	195/U	12"	IF ATTENUATOR (IN)	J311	75 MC FILTER	J306
25	---	556161-015	195/U	30"	IF ATTENUATOR (OUT)	J317	IF VIDEO AMPL.	J601

NOTES:

1. Used only on Serial Nos. 1-20.

2. Unharnessed cable in analyzer.

b. Disconnect oscillator output at plug P204 (11, figure 5-23).

c. Remove the cable clamp (8, figure 5-20).

d. Remove the two screws securing the triode oscillator cover and remove the cover.

e. Loosen the rotor arm screw and remove the rotor arm.

f. Remove the four hexagonal screws securing the oscillator to the mounting casting and remove the oscillator from the Tuning Unit.

5-49. REPELLER TRACKING POTENTIOMETER REMOVAL. To remove the repeller tracking potentiometer, perform the following steps:

a. Unsolder the 3 wires at tracking potentiometer R257 (1, figure 5-23).

b. Remove the four screws on the high voltage board & remove the cover (2, figure 5-23).

c. Disconnect the heavy, red, repeller lead at the high voltage board.

d. Loosen the 2 hexagonal screws on the potentiometer collar (2, figure 5-23).

e. Remove the 3 screws from the phenolic triangle.

f. Slide the potentiometer (1, figure 5-23) off the shaft and remove from the Tuning Unit.

5-50. MARKER OSCILLATOR REMOVAL. To remove the marker oscillator, perform the following steps:

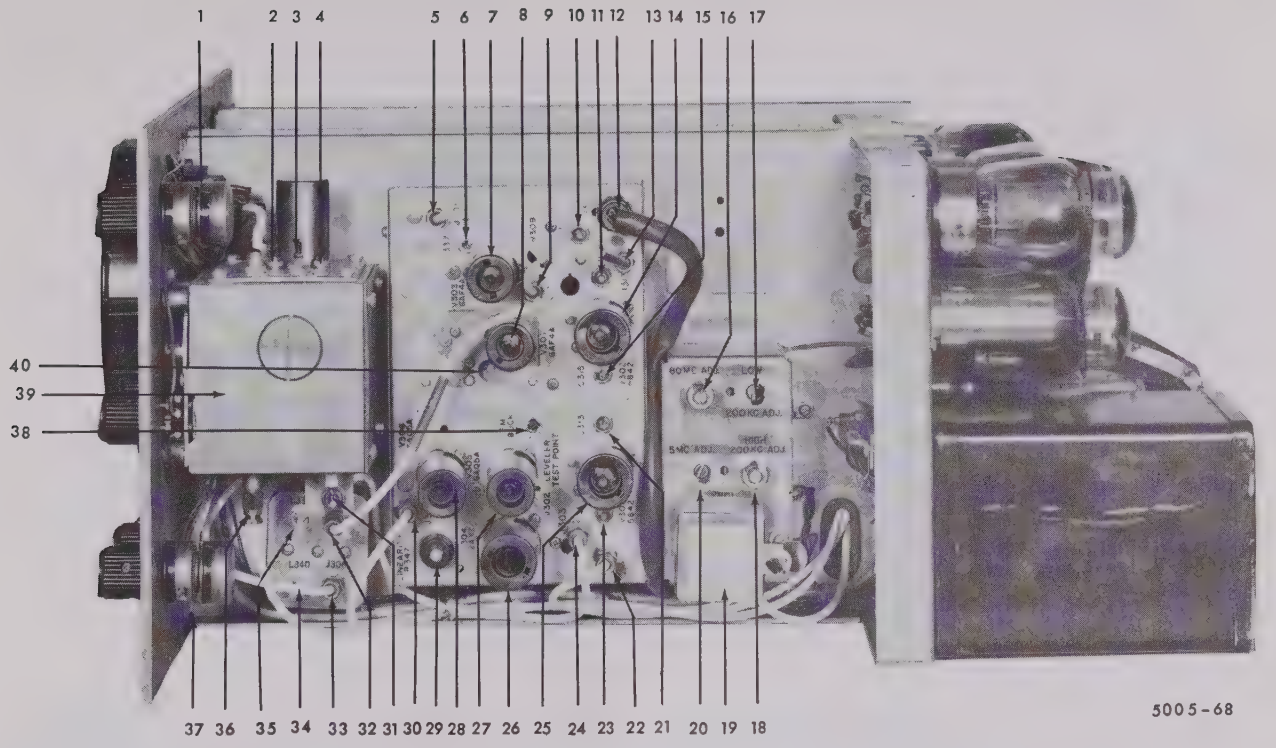
a. Without disconnecting any cables, remove the four screws securing the wideband chassis and swing the chassis clear.

b. Remove the MARKER FREQUENCY and MARKER LEVEL knobs.

c. Remove the four mounting screws and slide the marker oscillator clear until the connecting cables are accessible.

d. Disconnect the marker output cable from receptacle J403 (3, figure 5-16) and unsolder the marker modulation cable from receptacle J401 (31, figure 5-11). Loosen the nut on the mounting bracket and disconnect the marker modulation cable.

e. Unsolder the brown filament wire and the black ground wire from the case lugs; unsolder the red wire from the common terminal of the microswitch.



1. SWEEP RATE Potentiometer R285
2. Capacitor C405
3. Inductor L407
4. Capacitor C403
5. Receptacle J305
6. Inductor L337
7. Mixer Tube V303
8. Swept Oscillator Tube V307
9. Receptacle J315
10. Capacitor C331
11. Capacitor C327
12. Receptacle J309
13. Receptacle J313
14. 160 MC Amplifier Tube V302
15. Capacitor C315
16. 80 MC ADJ. Potentiometer R865
17. 200 KC ADJ LOW Potentiometer R867
18. 200 KC ADJ. HIGH Potentiometer R861
19. Relay K801
20. 5 MC ADJ. Potentiometer R871
21. Capacitor C313
22. Receptacle J301
23. Capacitor C303
24. Receptacle J303
25. 160 MC Amplifier Tube V301
26. AGC Amplifier Tube V304
27. AGC Amplifier Tube V305
28. Sawtooth Driver Tube V306
29. LINEARITY Potentiometer R347
30. Receptacle J307
31. Receptacle J401
32. Inductor L304
33. Receptacle J306
34. Inductor L340
35. Inductor L338
36. Receptacle J409
37. SWEEP WIDTH Potentiometer R863A/B
38. FM BUCK Potentiometer R346
39. Marker Oscillator
40. Center Frequency Adjustment Capacitor C361

Figure 5-11. Indicator Unit — Right Hand View

f. Remove the marker oscillator from the analyzer.

NOTE

The installation procedure for the marker oscillator is essentially the reverse of the above steps.

5-51. KLYSTRON CAVITY REMOVAL. To remove the klystron, perform the following steps:

a. Disconnect the klystron power plug (9, figure 5-20) and the klystron output plug P213 (12, figure 5-23).

b. Unsolder the repeller voltage lead from the red MOD jack J212 (4, figure 5-18).

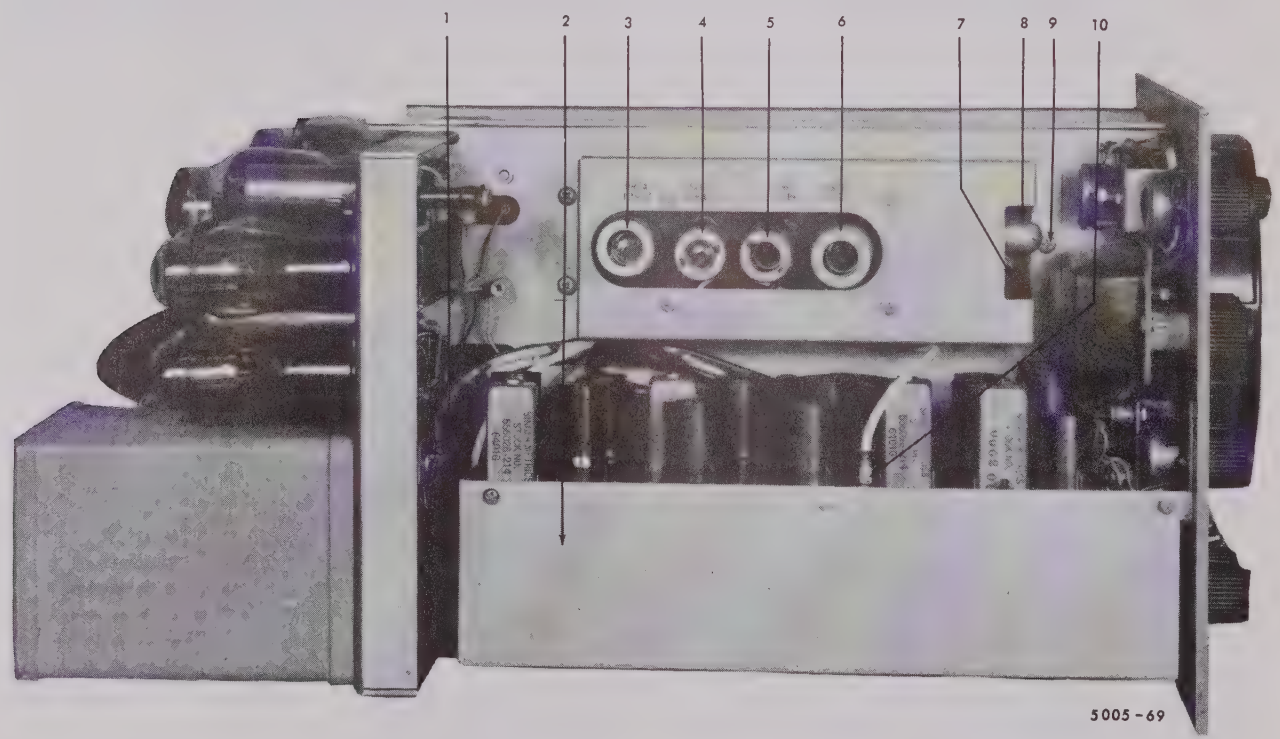
c. Remove the center position adjustment screw (7, figure 5-18) and tension spring (10, figure 5-20) from the yoke (8, figure 5-18) and crossbar (11, figure 5-20).

d. Remove the cavity mounting clamp (8, figure 5-20) and slide the klystron assembly (10, figure 5-23) out of the gear casting.

NOTE

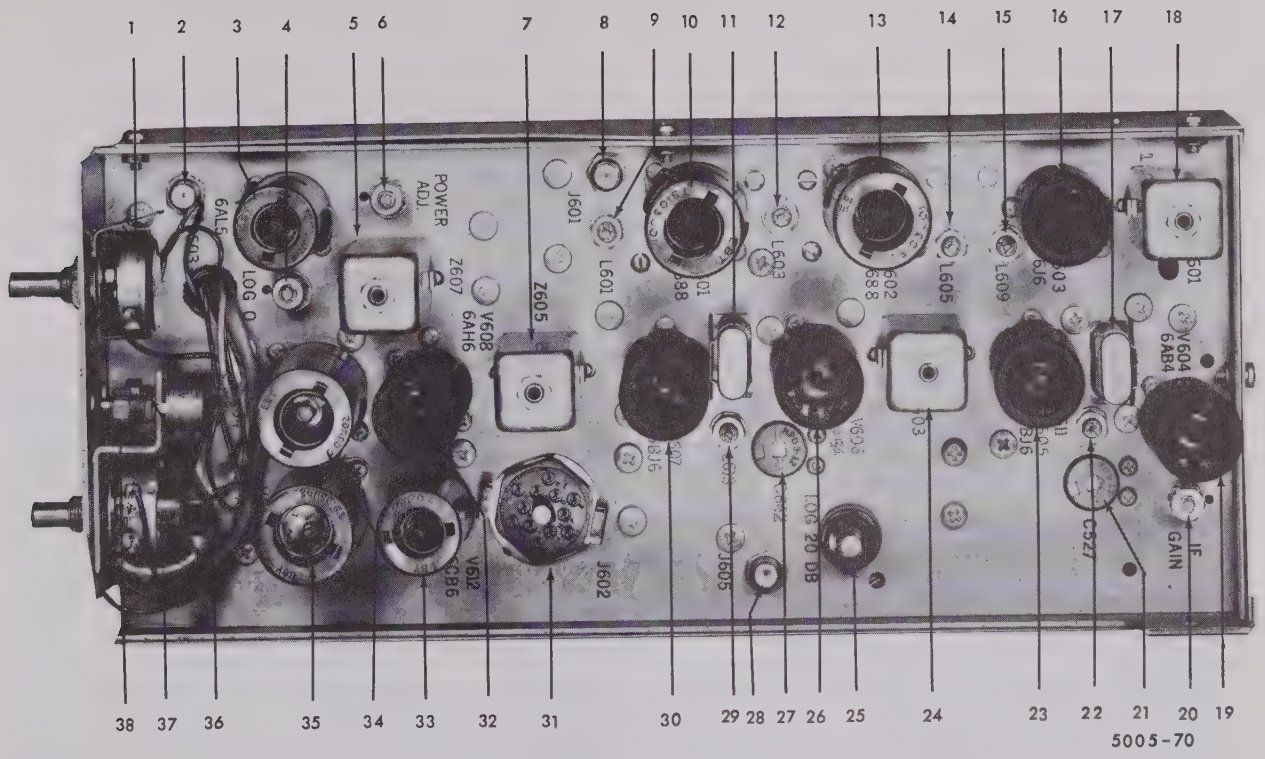
It may be helpful to unfasten the klystron mounting board and move it out of the way when working on the klystron cavity.

5-52. KLYSTRON TUBE REMOVAL. To remove the klystron tube from the cavity, perform the following steps:



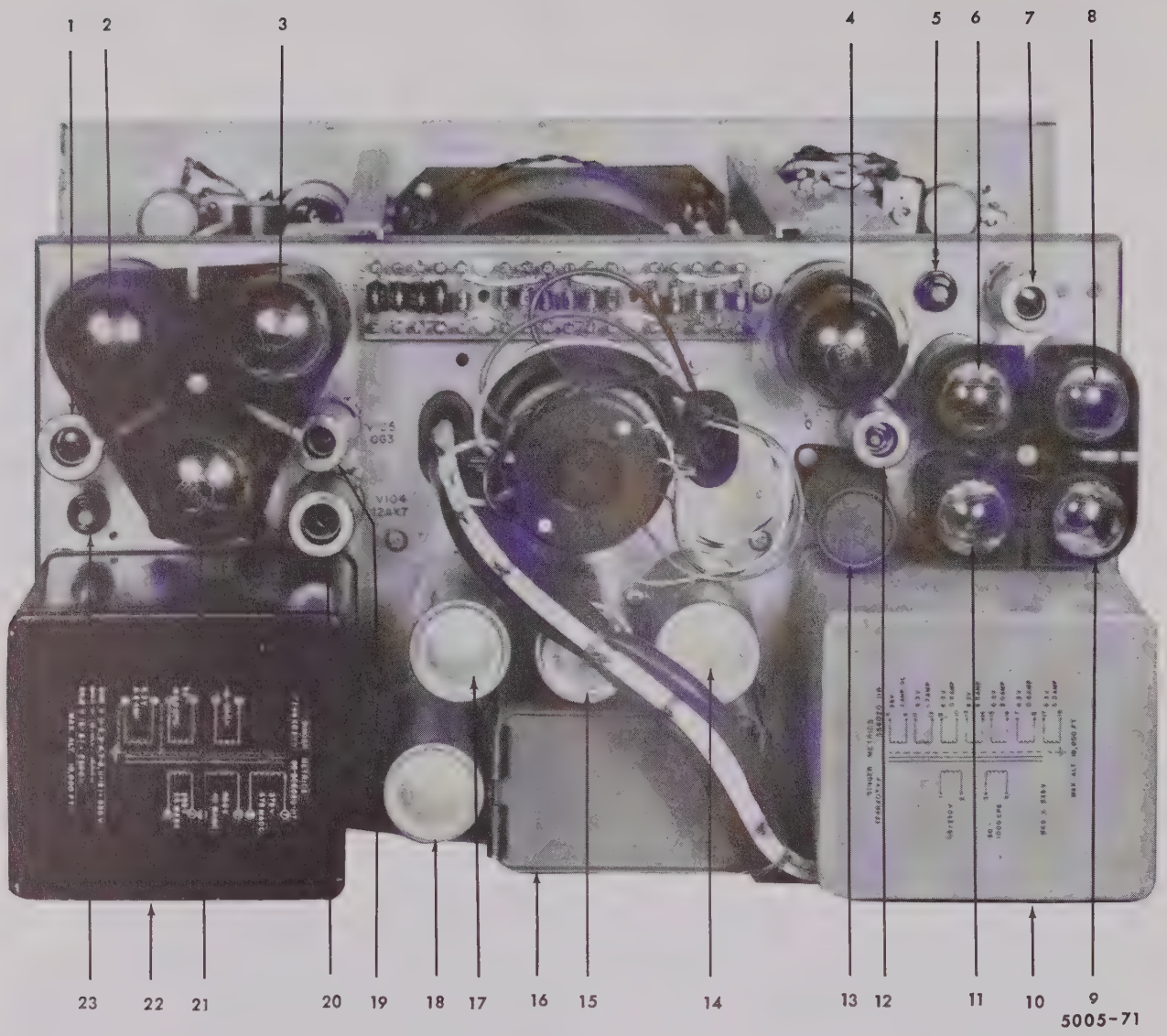
1. Power Supply Terminal Board
2. IF-Video Chassis (See figure 5-13.)
3. Horizontal Amplifier Tube V804
4. Cathode Follower Tube V803
5. Sawtooth Generator Tube V802
6. Sync Amplifier Tube V801
7. Lamp DS801
8. Neon E801
9. Horizontal Chassis Retaining Screw
10. Plug P601

Figure 5-12. Indicator Unit — Left Hand View



1. INTENSIFIER Potentiometer R686
2. Receptacle J603
3. Detector Tube V609
4. LOG 0 Potentiometer R659
5. Coil Z607
6. POWER ADJ. Potentiometer R657
7. Coil Z605
8. Receptacle J601
9. Inductor L601
10. 75 MC Amplifier Tube V601
11. Crystal CR602
12. Inductor L603
13. 75 MC Amplifier Tube V602
14. Inductor L605
15. Inductor L609
16. Mixer-Oscillator Tube V603
17. Crystal CR601
18. Coil Z601
19. Cathode Follower Tube V604
20. IF GAIN Potentiometer R637
21. Capacitor C627
22. Inductor L611
23. 6.5 MC Amplifier Tube V605
24. Coil Z603
25. LOG 20 DB Potentiometer R650
26. Cathode Follower Tube V606
27. Capacitor C642
28. Receptacle J605
29. Inductor L613
30. 6.5 MC Amplifier Tube V607
31. Receptacle J602
32. 6.5 MC Amplifier Tube V608
33. Blanker Tube V612
34. Vertical Amplifier Tube V610
35. Intensifier Tube V611
36. V POS Potentiometer R671
37. VIDEO FILTER Potentiometer R667
38. ASTIG Potentiometer R651

Figure 5-13. IF-Video Chassis



1. DC Amplifier Tube V106
2. Series Regulator Tube V101
3. Series Regulator Tube V102
4. Series Regulator Tube V108
5. -350 V Adjustment Potentiometer R161
6. Voltage Regulator Tube V113
7. DC Amplifier Tube V109
8. Voltage Regulator Tube V112
9. Voltage Regulator Tube V111
10. Transformer T102
11. Voltage Regulator Tube V110
12. Voltage Regulator Tube V107
13. Capacitor C117
14. Capacitor C111
15. Capacitor C107
16. Capacitor C109
17. Capacitor C102
18. Capacitor C101
19. Reference Tube V105
20. DC Amplifier Tube V104
21. Series Regulator Tube V103
22. Transformer T101
23. +250 V Adjustment Potentiometer R137

Figure 5-14. Indicator Unit — Rear View

a. With the klystron cavity removed from the Tuning Head (paragraph 5-51) sight in line with one of the push rods (2, figure 5-24) of the center conductor assembly (8, figure 5-25) and mark a line with a pencil on the side of the barrel to show the positioning of the choke (9, figure 5-25) when reassembling the cavity.

b. Pull off the end bell assembly (1, figure 5-25) and unscrew and remove the tube retaining lock nut (2, figure 5-25).

c. Remove the tube retainer with spring contact (3, figure 5-25). It may be necessary to use a twisting motion to remove the retainer from the barrel assembly.

d. Remove the 6BL6 klystron tube (12, figure 5-25) from the spring fingers of the center conductor assembly with a twisting motion.

CAUTION

Twist only with a radial motion while applying a steady pull. Do not attempt to bend or warp the tube out since this may break it.

e. Unscrew the rear lock nut (6, figure 5-25) and pull out the center conductor (8, figure 5-25) and choke assembly (9, figure 5-25).

f. With the barrel assembly (10, figure 5-25) free and clear, hold it up to the light and sight through it, inspecting for dust specks. Use a magnifying glass for this purpose. Clean the inside of the barrel with a lint-free cloth or tissue paper dampened with an approved solvent. Reinspect for dust or lint particles. Make sure that the barrel is absolutely clean before reassembly.

g. Inspect the choke assembly (9, figure 5-25) for wear and for cracks in the ferrite absorber ring. A cracked ring should be replaced. Check the condition of the teflon guide buttons and the inner liner.

h. Inspect the condition of the inner conductor assembly; it should be smooth and clean. Using a very light pressure, roll the fingered end of the center conductor between the palm of one hand and a table top to compress and equalize the tension of the fingers.

CAUTION

Do not use too much pressure. It is sufficient to straighten the alignment of the fingers so that they will grip evenly about the grid of the klystron tube.

NOTE

If at any time the condition of detail parts is found to be unsatisfactory, they should be repaired. If facilities are not available for this, the complete klystron assembly should be returned to the factory for repair.

5-53. KLYSTRON TUBE REPLACEMENT. To replace the klystron tube perform the following steps:

a. Reassemble the choke (9, figure 5-25) and center conductor (8, figure 5-25). Align the push rods (5, figure 5-25) with the mark made on the outer barrel (step a, paragraph 5-52) and insert the center conductor into the barrel. Fasten the center conductor in place with the rear lock nut (6, figure 5-25).

b. Insert the 6BL6 klystron tube (12, figure 5-25) into the open end of the center conductor as far as it will go. The retaining fingers should cover most of the No. 2 grid of the tube.

c. Install the tube retainer (3, figure 5-25) with the coiled spring end facing the tube. Using a twisting motion, push it on until it clicks.

d. Replace the end bell assembly by first attaching the tube plug to the tube pins, then resetting the end bell in the same position it was previously.

5-54. KLYSTRON CAVITY REPLACEMENT. To replace the klystron cavity, perform the following steps:

NOTE

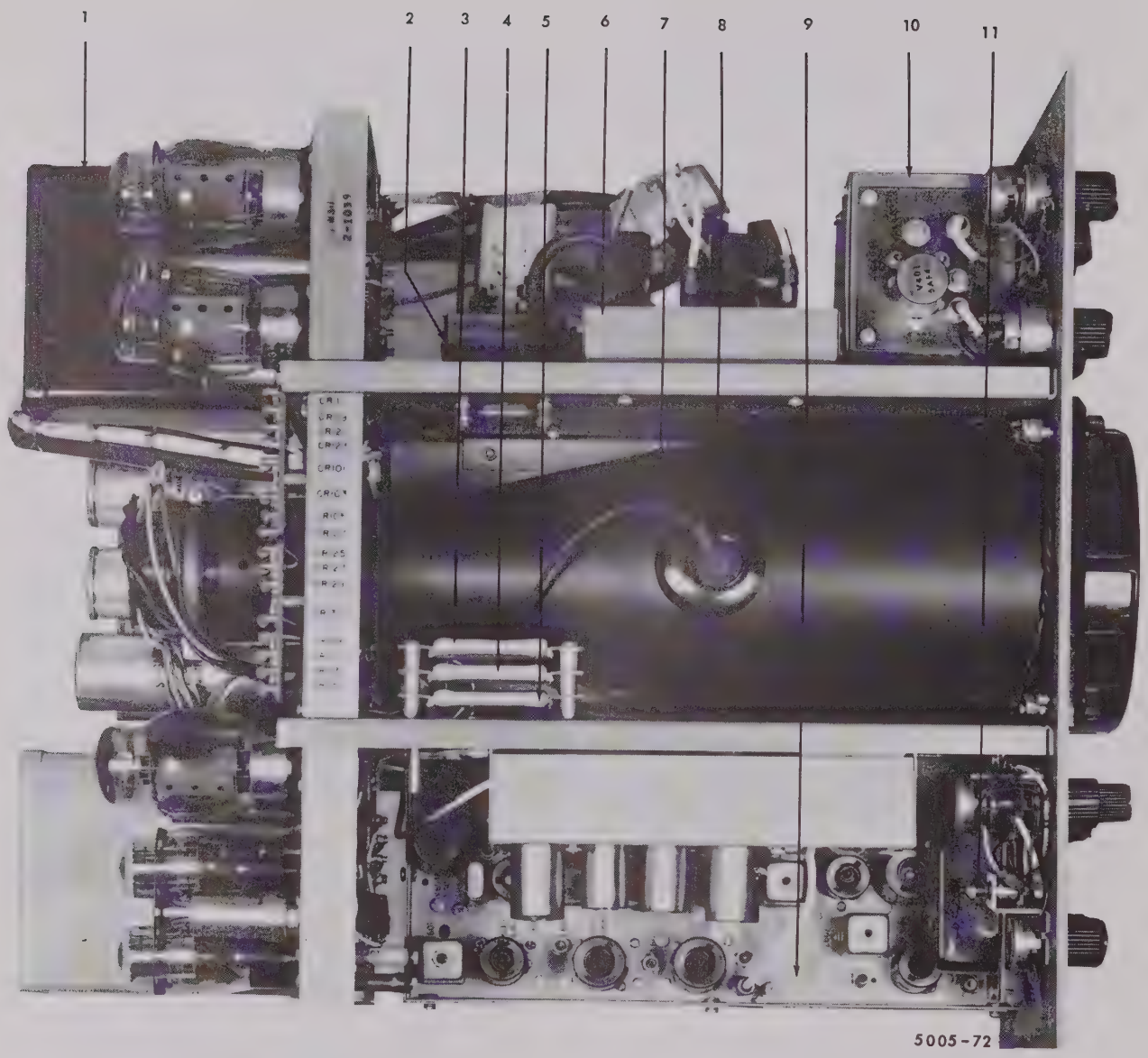
The cavity should be replaced in the same position and with the same orientation as previously installed so that tracking movement will not be hampered. The rear lock nut should butt up against the casting.

a. Install the cavity mounting clamp (8, figure 5-20) and replace the cavity lock.

b. Reconnect the klystron power plug (9, figure 5-20) and solder the repeller lead to the red MOD jack J212 (4, figure 5-18).

NOTE

Observe the three horizontal marks on the glass push rods. These marks indicate the two end limits of travel and the center frequency point.



1. Transformer T101
2. Sweep Relay Chassis
3. Resistor R185
4. Resistor R183
5. Resistor R181
6. Wideband Chassis
7. CRT Tube V701
8. Plug P105
9. IF-Video Chassis (See figure 5-13.)
10. Marker Oscillator
11. Coarse Spectrum Centering Potentiometer R367

Figure 5-15. Indicator Unit — Top View

c. Set the RANGE switch to the 3-12 KMC position and set the TUNING control to 3650 MC.

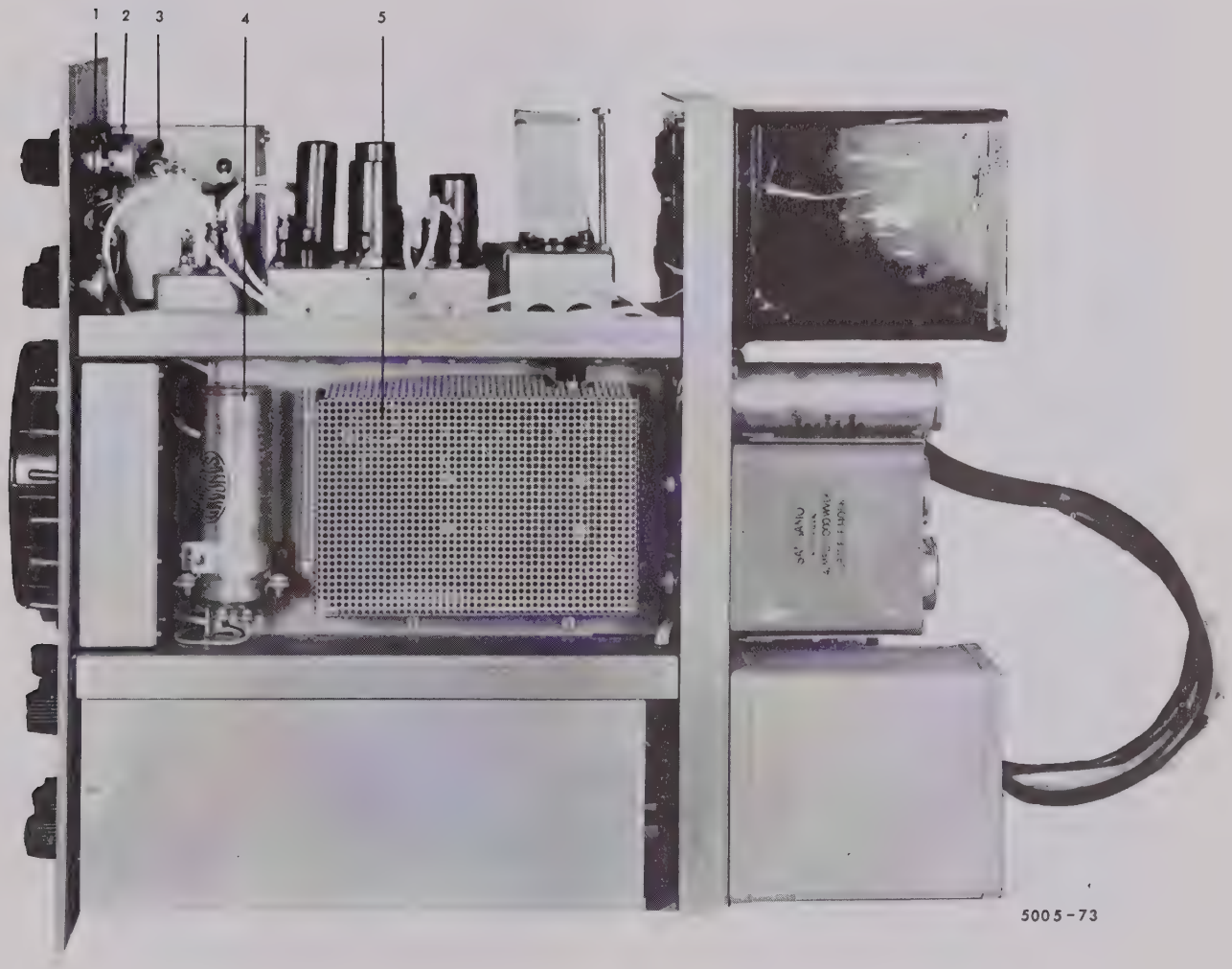
d. Install the center position adjustment screw (7, figure 5-18) with the tension spring (10, figure 5-20) between the yoke (8, figure 5-18) and the crossbar (11, figure 5-20). The tension spring should have its wider end resting on the yoke.

e. Turn the center position adjustment screw (7, figure 5-18) so that the center marks on the glass rods just emerge from the holes in the cavity.

NOTE

A proper adjustment will make the yoke fit with just enough play so that it will move freely when jiggled against the crossbar without a feeling of looseness.

f. If the center marks cannot be aligned properly with the adjustment screw alone,



1. IF ATTEN 20 DB Potentiometer R612
2. SWEEP WIDTH Potentiometer R863 A/B
3. Receptacle J403
4. Capacitor C133
5. CRT Power Supply (See figure 5-17.)

Figure 5-16. Indicator Unit — Bottom View

loosen the setscrews on the crossbar and adjust the height of the glass rods. Retighten the setscrews and repeat step e.

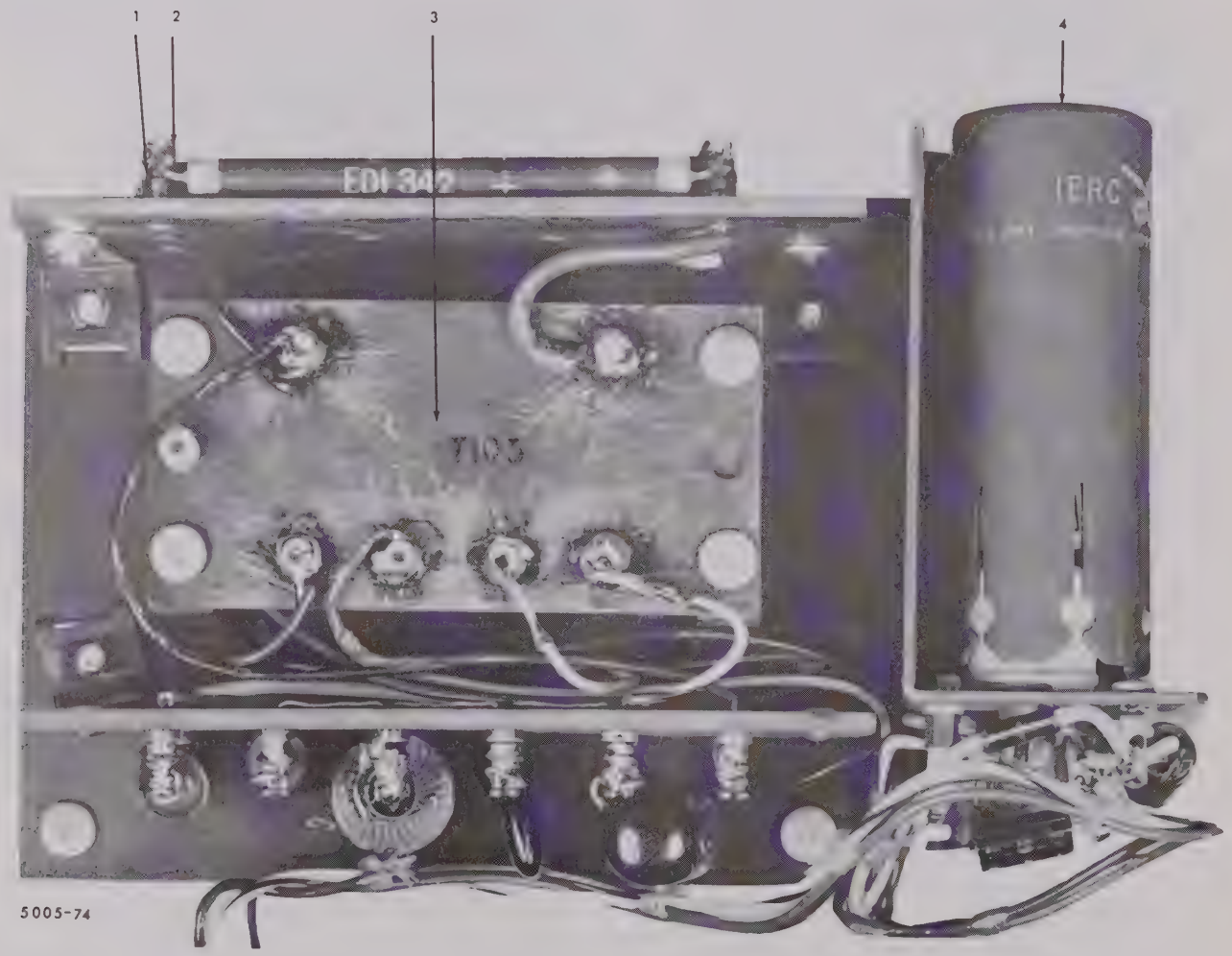
CAUTION

Retain a grip on the glass rods. If the choke assembly falls into the cavity, the choke may break the klystron tube.

g. Align the cavity following the procedure described in paragraph 5-98.

5-55. ADJUSTMENT AND ALIGNMENT.

5-56. GENERAL. The adjustment and alignment procedures are designed to compensate for a degradation in equipment performance resulting from variations in component value due to aging or replacement of detail parts. Since a complete realignment of the analyzer requires specialized experience and test equipment normally available only to factory service personnel, the following procedures have been limited to operations which experience has shown are capable of being performed in the field by competent technicians.

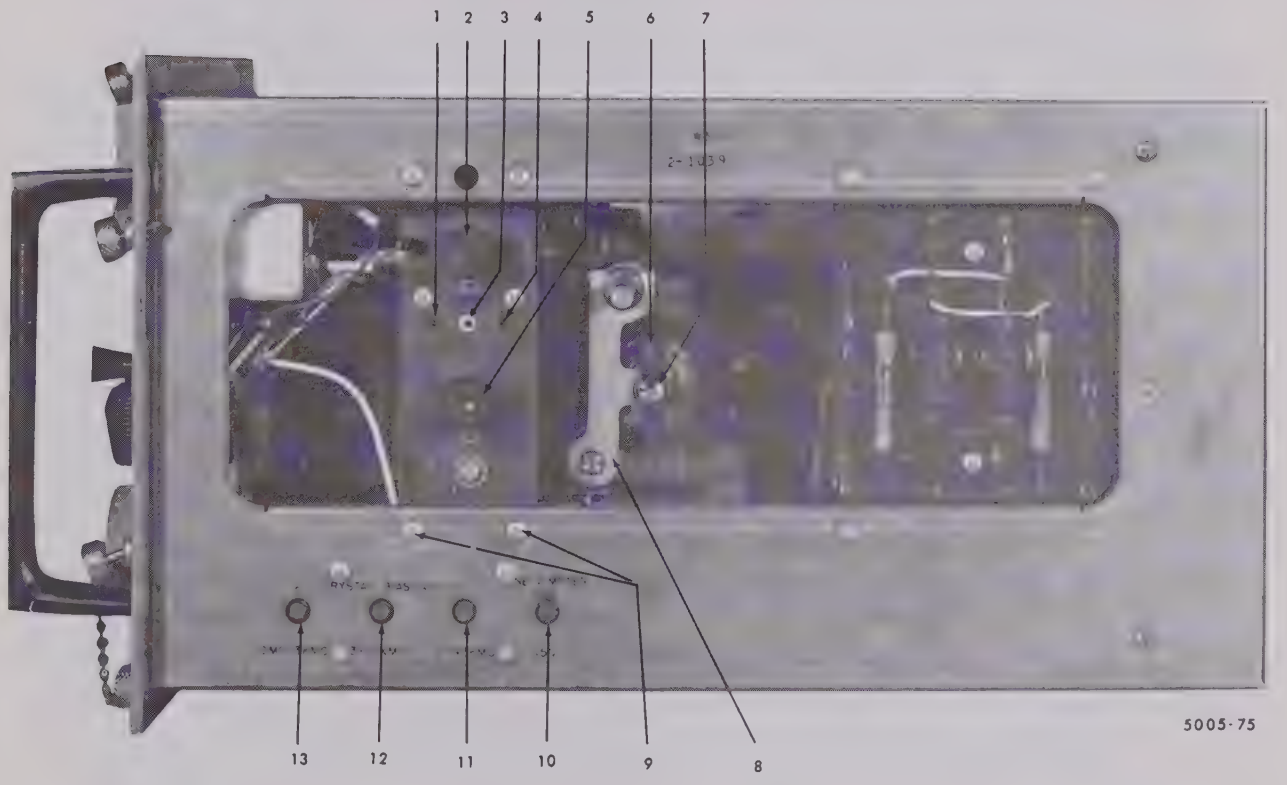


1. -2500 VDC Test Point
2. +2500 VDC Test Point (Under)
3. Transformer T103
4. 100 KC Oscillator Tube V114

Figure 5-17. CRT Power Supply — Cover Removed

5-57. The alignment procedures described in paragraphs 5-63 through 5-113 should be performed whenever equipment performance falls below the level required by the Minimum Performance Standards Checks or following the replacement of a detail part. In addition, these procedures provide a useful detailed test of equipment performance which can aid the maintenance technician in locating a defective component.

5-58. Alignment procedures progress from the output to the input of signal circuits so that the later sections of the circuits can be used to align the preceding sections. Optimum values are given, but some slight readjustment may be required to achieve best analyzer performance. As the alignment proceeds from stage to stage, it will usually be necessary to reduce the input signal level in order to maintain the CRT signal deflection below 3/4 scale

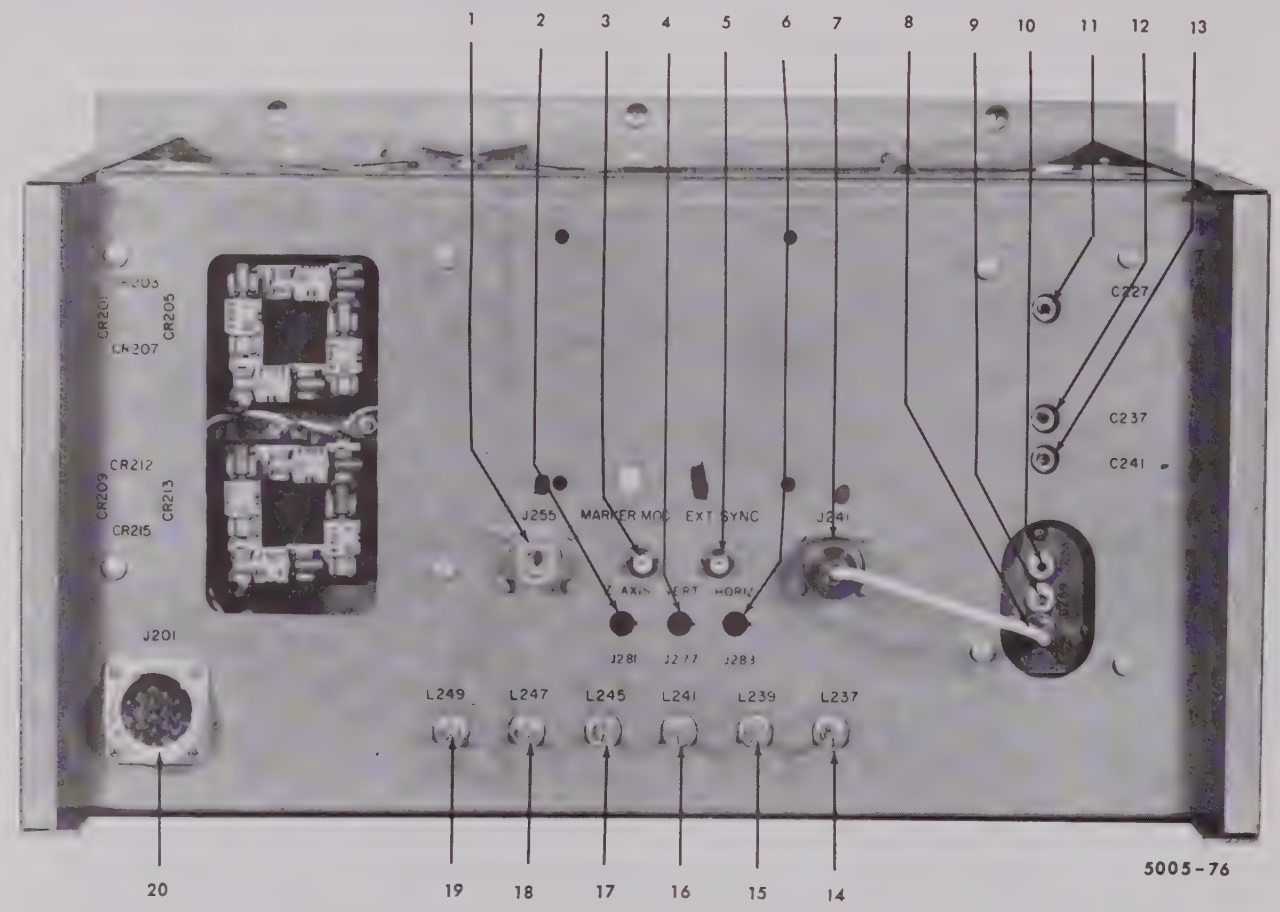


1. MOD Jack J214
2. Anode Voltage Adjustment HIGH Potentiometer R259
3. MOD Jack J210
4. MOD Jack J212
5. Anode Voltage Adjustment LOW Potentiometer R255
6. Crossbar
7. Center Position Adjusting Screw
8. Yoke
9. High Voltage Potentiometer Mounting Board Screws (Typical)
10. LINE V METER ADJ. Potentiometer R245
11. 12-43 KMC CRYSTAL BIAS ADJ. Potentiometer R237
12. 3-12 KMC CRYSTAL BIAS ADJ. Potentiometer R235
13. 10MC-3KMC CRYSTAL BIAS ADJ. Potentiometer R233

Figure 5-18. Tuning Head -- Right Hand View

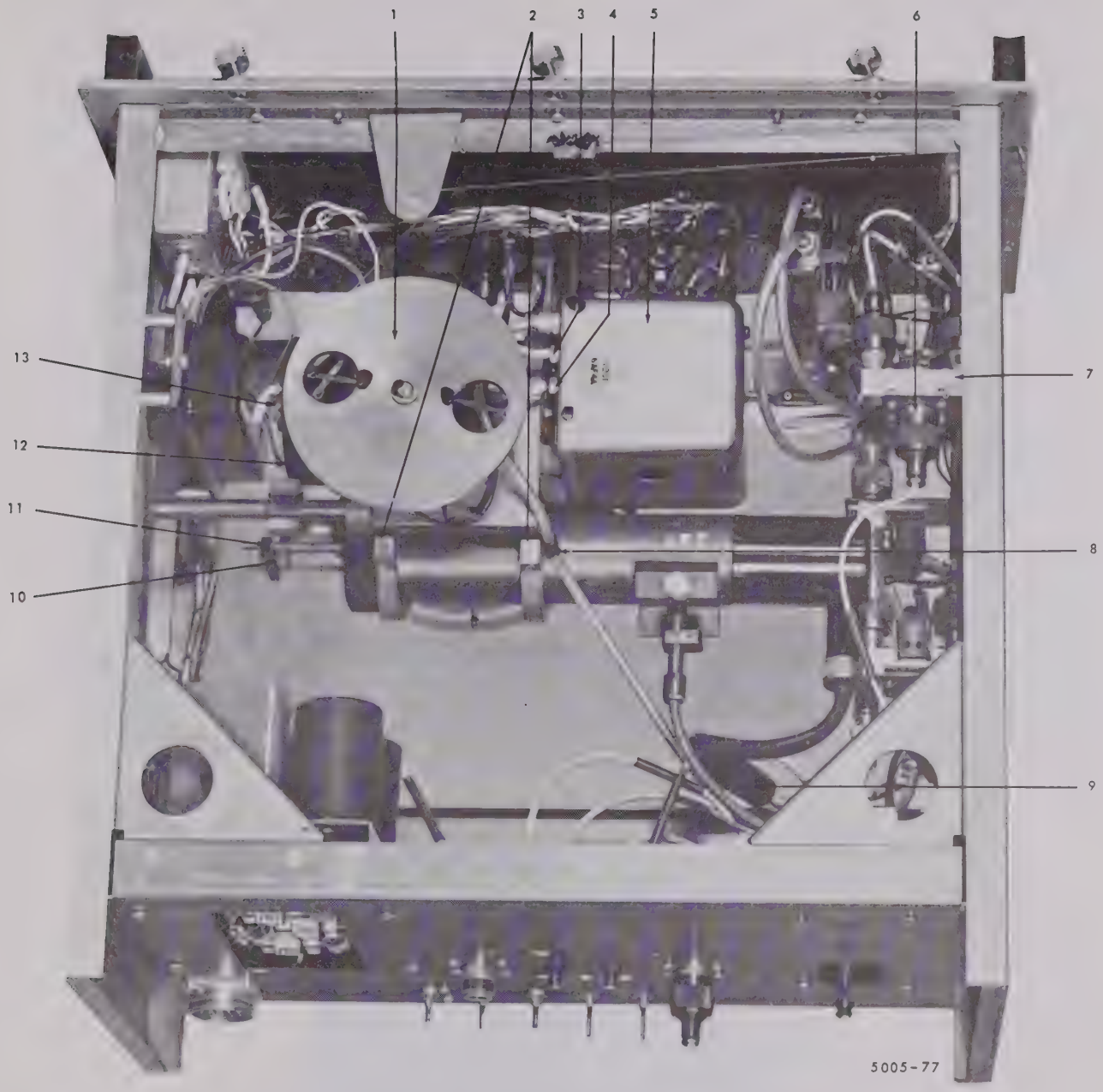
with at least 1/32-inch of noise to ensure against overloading the final stages.

5-59. Although the analyzer will operate satisfactorily with a line voltage ranging from 105 to 125 VAC, the procedures described in this section require that the line voltage be maintained at 115 VAC at all times. In addition, it is advisable to use "cheater" power and signal cables to permit the removal of all subchassis for servicing. These cables should be from 4 to 6 feet long and should duplicate the



1. Receptacle J255
2. Z AXIS Receptacle J281 (Supplied with XYZ option)
3. MARKER MOD Receptacle J259
4. VERT Receptacle J277 (Supplied with XYZ option)
5. EXT SYNC Receptacle J261
6. HORIZ Receptacle J283 (Supplied with XYZ option)
7. Receptacle J241
8. Receptacle J237
9. Capacitor C259
10. Capacitor C253
11. Capacitor C227
12. Capacitor C237
13. Capacitor C241
14. Inductor L237
15. Inductor L239
16. Inductor L241
17. Inductor L245
18. Inductor L247
19. Inductor L249
20. Receptacle J201

Figure 5-19. Tuning Head — Rear View



1. Tuning Pulley
2. Klystron Clamps
3. Feed-thru Capacitor C204
4. Feed-thru Capacitor C202
5. Triode Oscillator Assembly
   (See figures 5-21 and 5-22.)
6. Plug P223
7. Relay K203
8. Clamp
9. Klystron Power Plug
10. Spring
11. Cavity Crossbar
12. Tracking Potentiometer R257
13. Potentiometer Collar

Figure 5-20. Tuning Head — Top View

materials, wiring, and connectors of the originals. The following alignment procedures are based on the use of these cables.

5-60. All tunable coils and transformers are tuned by means of movable iron cores. Windings at the top and bottom of the coil are tuned with a hollow iron core which may be tuned with the hex end of the aligning tool supplied with the analyzer. The bottom windings may be tuned from either the top or bottom of the transformer. When the bottom coil is approached from the top, the aligning tool is inserted through the hollow top core, engaging the slot at the top of the lower core.

CAUTION

Do not force these cores beyond the first sign of resistance in either direction. Excessive torque may crack the cores or cause them to "freeze" necessitating replacement of the complete transformer.

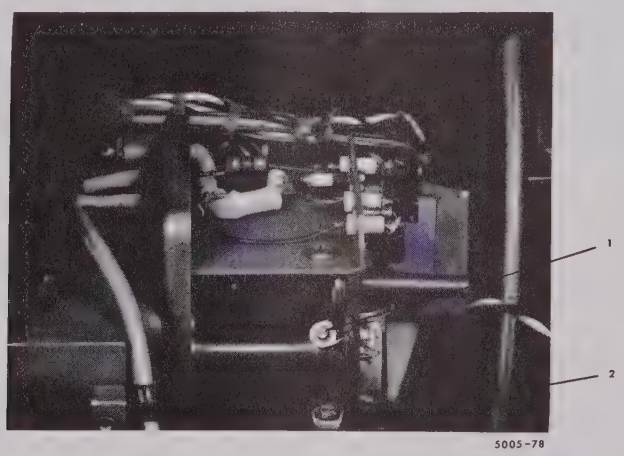
5-61. Variable glass trimmer capacitors, located in the triode oscillator preamplifier and wideband amplifier chassis, should be tuned using the alignment tools (Walsco No. 2519, No. 2541, and No. 2543) supplied with the analyzer. In addition, some adjustment of the air-core RF coils may be required. The adjusting procedures for these coils cannot be described in detail since they involve a simultaneous bending of various coil loops while monitoring analyzer performance. Although the desired analyzer response is indicated for each stage, the tuning of these air-core coils is so difficult for inexperienced personnel that their adjustment is discouraged. If the required performance cannot be obtained using the indicated adjustments, it is recommended that the analyzer be returned to the factory for servicing.

5-62. All voltage measurements are made to chassis ground and with the power supplies fully loaded unless otherwise specified. A dummy load may be substituted for various subchassis loads when checking or adjusting the power supplies, however disconnecting a subchassis in the event of a short circuit will not seriously affect power supply measurements.

NOTE

Before attempting analyzer alignment, turn on the analyzer and the required signal generators and provide a one-half hour warm-up period.

5-63. PRELIMINARY CONTROL SETTINGS. Unless otherwise indicated, the operating controls should be set to the positions listed in the following tabulation prior to each alignment procedure.



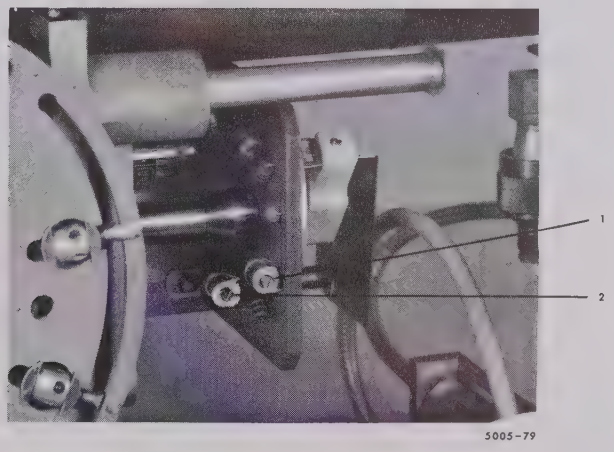
1. 400 MC Trimmer Capacitor C209
2. 150 MC Trimmer Capacitor C207

Figure 5-21. Triode Oscillator — Top View (Cover Removed)

CONTROL	POSITION
SWEEP WIDTH	Fully clockwise
IF BANDWIDTH	Fully clockwise
BRILLIANCE	Desired trace brightness
INTENSIFIER	Fully counterclockwise
FOCUS	Sharp trace
SPECTRUM CENTERING	Center
AMPLITUDE SCALE	LIN
IF ATTENUATOR (Switches)	Down
IF ATTEN 20 DB	1/8 inch noise on CRT
CAL SYNC SEL	LINE
SWEEP RATE	30 cps
SYNC AMPL	Stable display
VIDEO FILTER	Fully counterclockwise

CONTROL	POSITION
MARKER FREQUENCY	0
MARKER LEVEL	OFF
RANGE	10MC-3KMC
INTERNAL CHECK	XTAL BIAS
TUNING	As required by applicable paragraphs
RF ATTENUATOR	100

5-64. PRELIMINARY CHECKS AND ADJUSTMENTS. Prior to alignment, the analyzer should be thoroughly checked and adjusted in accordance with paragraphs 5-8 through 5-28. These procedures have been arranged in sequence and should be performed in the order indicated. Failure of the analyzer to meet the requirements of one or more of these procedures indicates a trouble is present in the equipment. Since the following procedures are fairly detailed, the general area of such a trouble should be readily apparent and the defective component can be determined using the voltage and resistance measurements listed in table 5-5.



1. 50 MC Trimmer Capacitor C205
2. 10 MC Trimmer Capacitor C203

Figure 5-22. Triode Oscillator — Top View (Cover Removed)

5-65. The check and adjustment procedures are arranged in groups representing the physical location of the major components being checked. In addition, these groups are sequenced so that a minimum number of circuits are being evaluated by individual procedures. Aside from the power supply checks, the procedures are arranged in inverted order so that checking proceeds from the CRT circuit back along the signal path to the wideband amplifier and the Tuning Head. Only when all these circuits have been checked can the actual alignment procedures be performed.

NOTE

Each check is complete in itself and does not require any equipment hook-ups described in a previous test. At the conclusion of each check, all test equipment should be disconnected in preparation for the next procedure.

5-66. POWER SUPPLY CHECKS AND ADJUSTMENTS. To check the power supply, set the operating controls to the positions listed in paragraph 5-63 and perform the procedures described in paragraphs 5-67 through 5-69.

5-67. LOW VOLTAGE POWER SUPPLY. To check and adjust the +250, -350, and -150 VDC low voltage power supply circuits, perform the following steps:

a. With analyzer power on, check that VR tube V105 (19, figure 5-14) is lighted.

b. Connect a VTVM to pin 6 of tube V106 (1, figure 5-14). Adjust the +250 V ADJ potentiometer R137 (23, figure 5-14) for a meter indication of +250 VDC.

c. Connect a calibrated oscilloscope to pin 6 of tube V106 (1, figure 5-14). Check that the line ripple is less than 5 millivolts.

d. Connect a VTVM to pin 5 of tube V113 (6, figure 5-14). Adjust the -350 V ADJ potentiometer R161 (5, figure 5-14) for an indication of -350 VDC.

e. Connect a calibrated oscilloscope to pin 5 of tube V113. Check that the line ripple is less than 20 millivolts.

f. Connect a VTVM to pin 2 of tube V107 (12, figure 5-14). Check that the meter indicates approximately -150 VDC.

g. Connect a calibrated oscilloscope to pin 2 of tube V107. Check that the line ripple is less than 3 millivolts.

5-68. KLYSTRON POWER SUPPLY. The klystron power supply is located in the Indicator Unit. The -950 and -350 VDC voltages are fed into the Tuning Head through pin 10 and 7 (respectively) of connector J201, through the RANGE switch S201 to the klystron. By referring to the applicable schematic diagram, it will be noted that these voltages are applied to the klystron only when the RANGE switch is in the 3-12 KMC positions or 12-43 KMC positions. Accordingly it is recommended that the RANGE switch be set to the 10 MC-3KMC position except when actually operating in the higher bands. This practice ensures that the klystron is energized only when necessary and materially lengthens klystron life.

WARNING

High voltages are present in this area. Use appropriate safety precautions.

5-69. The -350 VDC klystron cathode bias voltage was checked previously in accordance with paragraph 5-59. To check the -950 VDC klystron repeller voltage, connect a VTVM to pin 2 of tube V110 (11, figure 5-14). Note that the level of the -950 and -350 VDC voltages are both determined by the setting of the -350V ADJ potentiometer R161 (5, figure 5-14).

5-70. HORIZONTAL CHASSIS CHECKS AND ADJUSTMENTS. To check the horizontal chassis, set the operating controls to the positions listed in paragraph 5-63 and perform the procedures listed in paragraphs 5-71 through 5-76.

5-71. SWEEP RATE. Check the operation of the sweep rate circuit in accordance with the following steps:

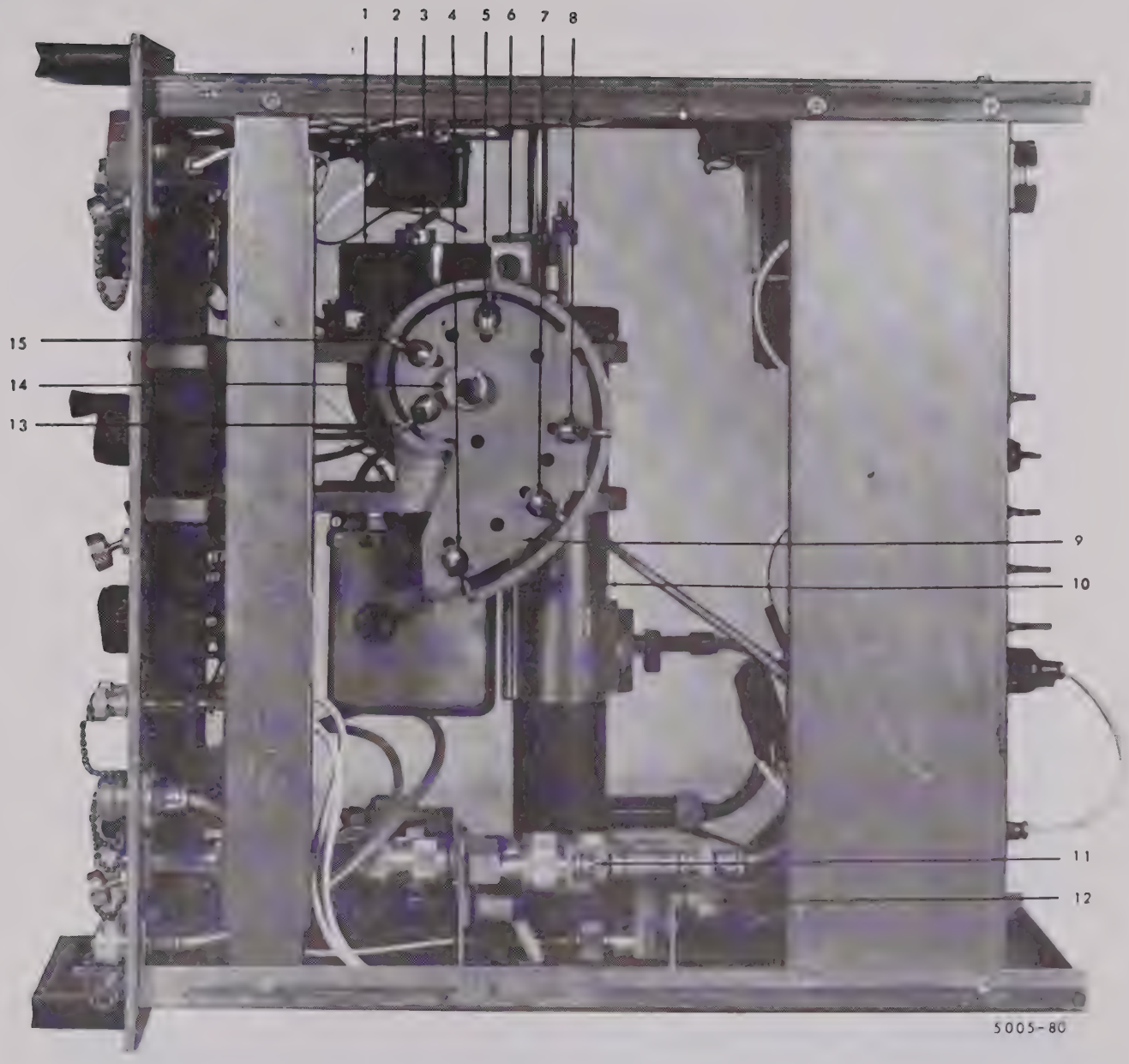
a. Connect the vertical input lead of an oscilloscope to pin 6 of horizontal amplifier V804 (3, figure 5-12).

b. Rotate the SWEEP RATE and SYNC AMPL controls fully counterclockwise.

c. Check that the scope indicates a sweep rate of less than 1 cps but does not stop.

d. Rotate the SWEEP RATE control fully clockwise and check that the sweep rate exceeds 60 cps. [Check that lamp DS801 (7, figure 5-12) is lighted.]

5-72. If it is not possible to obtain either or both of the above sweep rates, it is likely that neon E801 is not functioning properly. This lamp is an NE-16 coated with a special con-



1. Tracking Potentiometer R257
2. High Voltage Cover
3. Potentiometer Collar
4. Cam Adjusting Screw No. 6
5. Cam Adjusting Screw No. 3
6. Cam Follower
7. Cam Adjusting Screw No. 5
8. Cam Adjusting Screw No. 4
9. Cam Assembly
10. Klystron Assembly
11. Plug P204
12. Plug P213
13. Cam Adjusting Screw No. 1
14. Cam Hub
15. Cam Adjusting Screw No. 2

Figure 5-23. Tuning Head — Bottom View

ductive paint and serves as the triggering device for the sawtooth generator V802. Replace a defective lamp with a pretested bulb that will fire at 60 VAC or less. It should be painted with a conductive paint in a similar fashion to the original since the paint acts as a capacitive pick-up for the 60 cps sync voltage. If the replacement of this lamp does not provide proper triggering, experiment with different values for resistors R827 and R831 using a suitable decade resistor box.

5-73. SYNC AMPLITUDE. Check the operation of the sync amplitude circuit in accordance with the following steps:

a. Connect the vertical input lead of an oscilloscope to pin 6 of horizontal amplifier V804 (3, figure 5-12).

b. With the SYNC AMPL control fully counterclockwise, adjust the SWEEP RATE control for a 60 cycle display on the oscilloscope. (Refer to NOTE following step d, paragraph 5-17.) Detune the SWEEP RATE control slightly so that the signal moves slowly across the scope screen.

c. Slowly rotate the SYNC AMPL control clockwise until the signal locks in. This should occur at approximately $\frac{1}{2}$ turn.

5-74. EXTERNAL SYNCHRONIZATION. Check the operation of the external synchronization circuit in accordance with the following steps:

a. Connect the vertical input lead of an oscilloscope to pin 6 of horizontal amplifier V804 (3, figure 5-12).

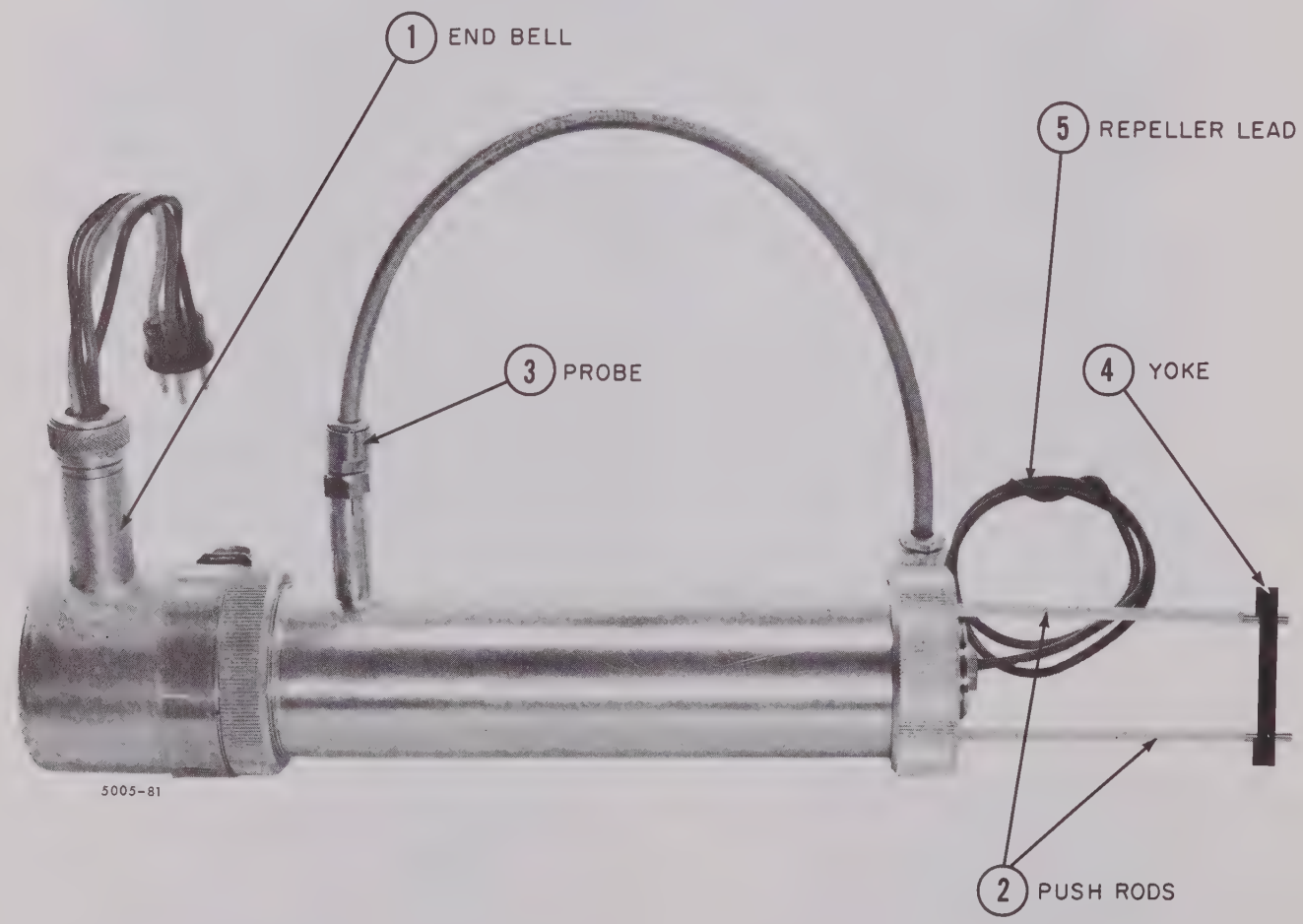


Figure 5-24. Klystron Cavity — Assembled (Typical)

b. Set the CAL SYNC SEL switch to the EXT position and rotate the SYNC AMPL control fully counterclockwise.

c. Connect the output lead from an audio oscillator to the EXT SYNC receptacle on the front panel of the analyzer. Adjust oscillator output for 60 ±1 cps at 3 volts RMS.

d. Rotate the SYNC AMPL control clockwise approximately $\frac{1}{2}$ turn and check that the signals on both the SCOPE and analyzer CRT lock in.

5-75. LINE SIZE. Check the operation of the baseline size circuit in accordance with the following steps:

a. Connect the vertical input lead of an oscilloscope to the junction of capacitor C813 and LINE SIZE potentiometer R837.

b. Check that the scope indicates a sawtooth signal of from 45-60 volts P-P. (A high reading is preferable.)

5-76. HORIZONTAL POSITIONING. Check the operation of the horizontal positioning circuit in accordance with the following steps:

a. Connect the vertical input lead of an oscilloscope to pin 6 of horizontal amplifier V804 (3, figure 5-12).

b. Slowly rotate the H POS control counterclockwise. Check that the sawtooth signal on the oscilloscope becomes clipped at the top.

c. Set the H POS control to approximately center travel and check that the sawtooth is undistorted. The signal level should be approximately 120 volts P-P.

d. Connect the scope lead to pin 1 of V804 (3, figure 5-12).

e. Slowly rotate the H. POS control clockwise. Check that the sawtooth signal on the oscilloscope becomes clipped on the top.

f. Set the H POS control to approximately center travel and check that the sawtooth is undistorted. The signal level should be approximately 140 volts P-P.

g. Return the H POS control to its normal position in accordance with paragraph 5-18.

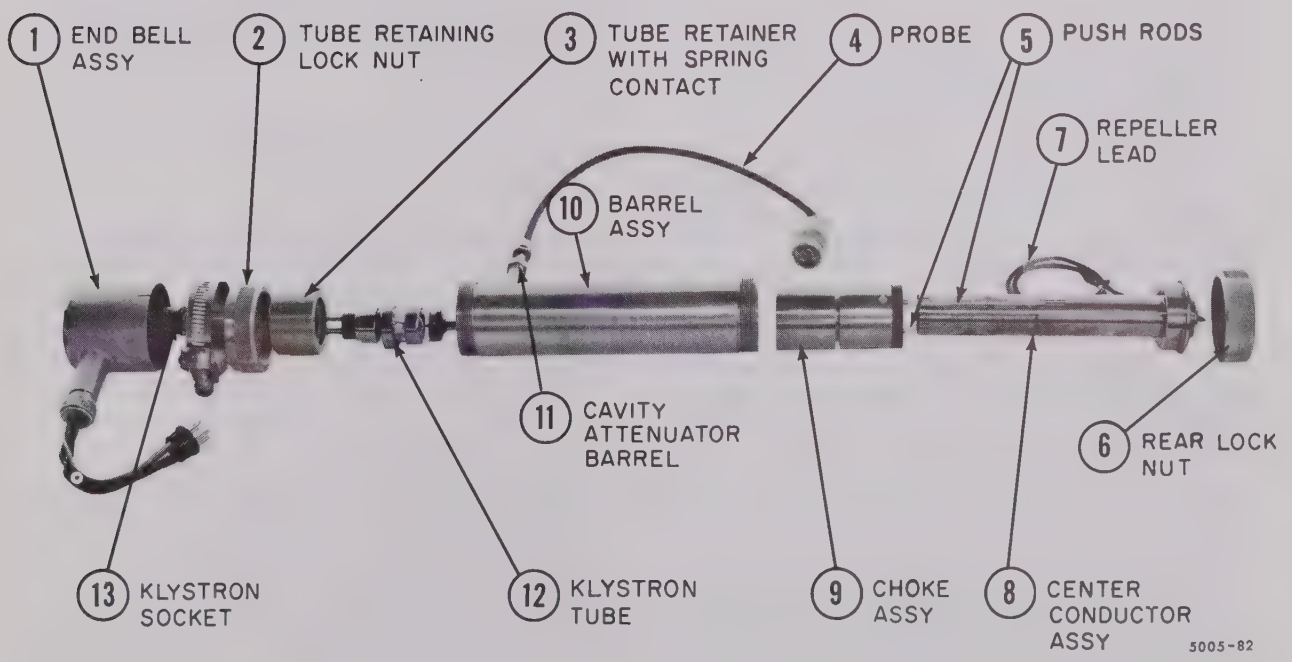


Figure 5-25. Klystron Cavity — Disassembled (Typical)

5-77. IF-VIDEO CHASSIS CHECKS AND ADJUSTMENTS. To check the IF-video chassis, set the operating controls to the positions listed in paragraph 5-63 and perform the procedures listed in paragraphs 5-78 through 5-82.

5-78. VERTICAL GAIN. Check the gain of vertical amplifier V610 in accordance with the following steps:

a. Remove the detector tube V609 (3, figure 5-13) and connect the vertical input lead of an oscilloscope to pin 8 of vertical amplifier V610 (34, figure 5-13).

b. Connect the output lead of an audio oscillator to pin 2 of detector V609 (socket) and adjust the oscillator for a 1000-cycle signal at 1.0 volt P-P. Check that an undistorted sine wave appears on the oscilloscope screen.

c. Replace detector tube V609.

5-79. VERTICAL POSITIONING. Check the operation of the vertical positioning circuit in accordance with the following steps:

a. Connect the vertical input lead of an oscilloscope to pin 6 of vertical amplifier V610 (34, figure 5-13).

b. Connect the output lead of an audio oscillator to pin 2 of detector V609 (3, figure 5-13) and adjust the oscillator for a 1000-cycle signal at 1.0 volt P-P.

c. Rotate the V POS control from fully clockwise to fully-counterclockwise and check that the signal voltage varies from 13 volts P-P up to 23 volts P-P, then returns to 13 volts P-P.

5-80. VIDEO FILTER. Check the operation of the video filter circuit in accordance with the following steps:

a. Connect the vertical input lead of an oscilloscope to pin 8 of vertical amplifier V610 (34, figure 5-13).

b. Connect the output lead of an audio oscillator to pin 2 of detector V609 (3, figure 5-13) and adjust the oscillator of a 1000 cycle signal and $\frac{1}{2}$ scale on oscilloscope screen.

c. Rotate the VIDEO FILTER control clockwise and note that the oscilloscope signal reduces in amplitude.

5-81. INTENSIFIER AND BLANKING. Check the operation of the intensifier and blanking circuits in accordance with the following steps:

a. Connect the vertical input lead of an oscilloscope to receptacle J605 (28, figure 5-13).

b. Adjust the MARKER LEVEL control for a full scale pip on the analyzer CRT screen with the IF BANDWIDTH control adjusted for minimum baseline noise.

c. Check that the blanking pulse appears as a negative pip approximately 120 volts P-P under the oscilloscope baseline.

d. Rotate the INTENSIFIER control fully clockwise and check that the marker pip appears as a positive pulse approximately 20 volts P-P above the oscilloscope baseline.

5-82. ASTIGMATISM. Check the operation of the astigmatism circuit in accordance with the following steps:

a. Connect a VTVM to pin 1 of intensifier V611 (35, figure 5-13).

b. Rotate the ASTIG control slowly from fully clockwise to fully counterclockwise and check that the voltage rises from approximately +45 to +195 VDC.

5-83. TUNING HEAD CHECKS AND ADJUSTMENTS.

5-84. LINE VOLTAGE METER ADJUSTMENT. The line voltage meter circuit permits the operator to monitor the external line voltage applied to the analyzer. To adjust the meter circuit for maximum accuracy, connect the analyzer power cord to a Variac and perform the following steps:

a. Connect an accurate AC voltmeter in parallel with the Variac output and adjust the Variac for a nominal 115 VAC.

b. Turn on the analyzer and set the INTERNAL CHECK switch to the LINE V position.

c. Adjust the Variac for exactly 115 VAC on the AC voltmeter and adjust potentiometer R245 (10, figure 5-18) for a 115 VAC indication on the internal check meter.

NOTE

The horizontal lines scribed on the face of the internal check meter represent 2 volt increments.

The 115 VAC mark is located opposite the green N block.

d. Adjust the Variac for exactly 105 VAC and check that the internal check meter indicates 105±4 VAC.

e. Adjust the Variac for exactly 125 VAC and check that the internal check meter indicates 125±4 VAC.

f. Turn off the analyzer and the Variac and disconnect the test setup. Reconnect the analyzer directly to the external line source.

5-85. DIAL POINTER ADJUSTMENT. On rare occasions the dial pointer may slip on the dial cable causing an error in dial calibration. This trouble is indicated when the percentage of calibration error is greater at the high frequency end of the dial than at the low end.

5-86. To determine whether the dial pointer has slipped, rotate the TUNING control from fully counterclockwise to fully clockwise. The dial pointer should align with the reference line at the left hand side of the dial and travel to approximately 1/4 inch past the 700 MC calibration at the right hand side of the dial. If the pointer travel has shifted, the dial pointer must be reset.

NOTE

A "spongy" feel in TUNING control operation or dial pointer overtravel which is not the result of pointer slippage indicates a trouble in the drive gear train, usually in the gear shaft stops. Unless the user is equipped to handle the repair of the tuning gear train, it is recommended that the entire Tuning Head be returned to the factory for repair.

5-87. To readjust dial pointer calibration set the POWER SCALE ILLUM switch to the OFF position and perform the following steps:

a. Check that the dial cable is taut and in good condition without broken strands. If the cable is frayed, replace it in accordance with paragraph 5-88.

b. Rotate the TUNING control fully counterclockwise and slide the pointer along the cable until it is aligned with the reference line at the left hand side of the dial.

CAUTION

Do not attempt to force the pointer since excessive force may break the cable or damage the pointer. If it cannot be moved with minimum effort, loosen the clip by opening the ears slightly.

c. Clamp the retaining ears over the cable to hold it snugly but not tight enough to cut the cable.

d. Rotate the TUNING control fully clockwise and check that the dial pointer extends approximately 1/4 inch beyond the 700 MC calibration. Observe that the pointer moves smoothly with a minimum of lateral weaving. (If necessary, bend the pointer clip as required to ensure smooth travel.)

e. Wipe the track clean and apply a dab of lubricating grease (Lubriplate) on the track. Rotate the TUNING control back and forth to spread the grease along the track.

NOTE

If for any reason the dial pointer has to be adjusted or the cable replaced, a complete realignment of both the triode and klystron oscillators is required. Only then should a drop of plastic cement be applied to the pointer ears to prevent further adjustment.

5-88. DIAL CORD REPLACEMENT. To replace a broken or frayed dial cord, perform the following steps:

a. Rotate the TUNING control fully counterclockwise.

b. Remove the two screws at the top of the dial pulley (1, figure 5-20) and remove the two springs. Remove the old cable from the springs. (See figure 5-26.)

c. Spread the ears of the dial pointer and remove the cable from the pointer.

d. Unwind the old cable from the pulleys and remove from the analyzer.

e. Secure a 60 inch length of dial cord, 0.012 inch diameter, 7 strand, type 316 annealed stainless steel cable, nylon coated to a maximum diameter of 0.018 inches.

NOTE

This cable is currently available from the Bergen Wire Rope Company, Lodi, New Jersey. If this cable is unavailable, the 0.012 inch diameter, stranded stainless steel, "U control" model airplane cable available at most hobby shops will serve.

f. Knot one end of the cable to spring A using a series of half hitches and secure the spring to the pulley using the screw. Secure spring B to the pulley using the second screw.

g. Apply sufficient tension to the cable to expand spring A about 1/4 inch and take one turn around the tuning pulley in a counterclockwise direction.

h. Still maintaining cable tension, pass the wire clockwise around the center idler pulley, then counterclockwise around first the low frequency and then the high frequency idler pulleys.

i. Continuing to hold tension, pass the cable clockwise around the center idler pulley so that the cable falls above the first turn. Pass the cable end over the cable from spring A and clockwise around the dial pulley to spring B.

j. Pass the cable through the open loop of spring B and apply sufficient tension to expand the spring 1/4 inch. Fasten the cable to the spring using a series of half hitches.

k. Slide the dial pointer under both cables at the low frequency pulley and secure to the front cable by bending down the ears. Line up the pointer with the reference mark at the low end of the dial.

l. Rotate the TUNING control back and forth to equalize cable tension. Ensure that the cable is taut with no evidence of slackness and apply a drop of plastic cement to the cable knots at the springs.

NOTE

If further tensioning is required, rotate the TUNING control fully counterclockwise. Untie the wire at spring B and apply additional tension as required. Retie securely and repeat step 1.

m. Check the dial pointer adjustment in accordance with paragraph 5-85.

5-89. CRYSTAL BIAS ADJUSTMENT. Crystal bias adjustment should be performed only after crystal CR223 has been replaced or when testing indicates a loss in analyzer sensitivity traceable directly to a maladjustment of the crystal mixer biasing voltage. Since a loss of sensitivity can result from many causes (e.g., defective amplifiers, loose cables, bad relay contacts, etc.) these other potential sources should be definitely eliminated before adjusting crystal bias.

5-90. The range of adjustment of the crystal bias controls is relatively small and can normally produce an increase in sensitivity of only a few db. Accordingly, if the sensitivity of a particular band is substantially below the specifications listed in table 1-3 or if there is a considerable "hole" (sharp dip) extending down 10 or 15 db. the problem is probably not due to a faulty bias adjustment.

5-91. For special requirements, it is sometimes possible to adjust the bias controls to increase analyzer sensitivity at a specific frequency somewhat beyond the rated maximum. Unless this frequency is to be used to the exclusion of other frequencies within the affected bands, however, this practice is not recommended since it will tend to reduce the sensitivity at other points.

5-92. To adjust the crystal bias, set the operating controls to the positions listed in paragraph 5-18 and perform the following steps:

a. Plot the analyzer sensitivity for tuning band 1 (10-680 MC) in accordance with paragraph 5-28. Note and record the frequency and sensitivity of any points which fall below the minimum specification listed in table 1-3. (If no frequency is below specification, proceed to step d.)

b. Tune the analyzer and the signal generator to the frequency displaying the lowest sensitivity and set the INTERNAL CHECK switch to the XTAL BIAS position.

c. Adjust the 10 MC — 3 KMC crystal bias potentiometer R233 (13, figure 5-18) as required to increase the analyzer sensitivity at the test frequency to the minimum specified level.

NOTE

When adjusting the crystal bias potentiometers, two peaks of maximum sensitivity will be noted. Monitor the crystal bias on the internal check meter and adjust the potentiometer for the peak producing the desired sensitivity with the minimum bias voltage.

d. Plot the analyzer sensitivity for tuning band 2 (600 — 2360 MC) in accordance with paragraph 5-28. Note and record the frequency and sensitivity of any points which fall below the minimum specification listed in table 1-3. If one or more frequencies are below the required level, perform steps b. and c. for band 2, then repeat steps a. through c. for band 1. If no frequency is below specification, proceed to step e.

NOTE

Since each of the crystal bias potentiometers affects more than one band, any change in the control setting to correct a sensitivity defect in one band requires a recheck of the other band to ensure against a sensitivity loss in that band.

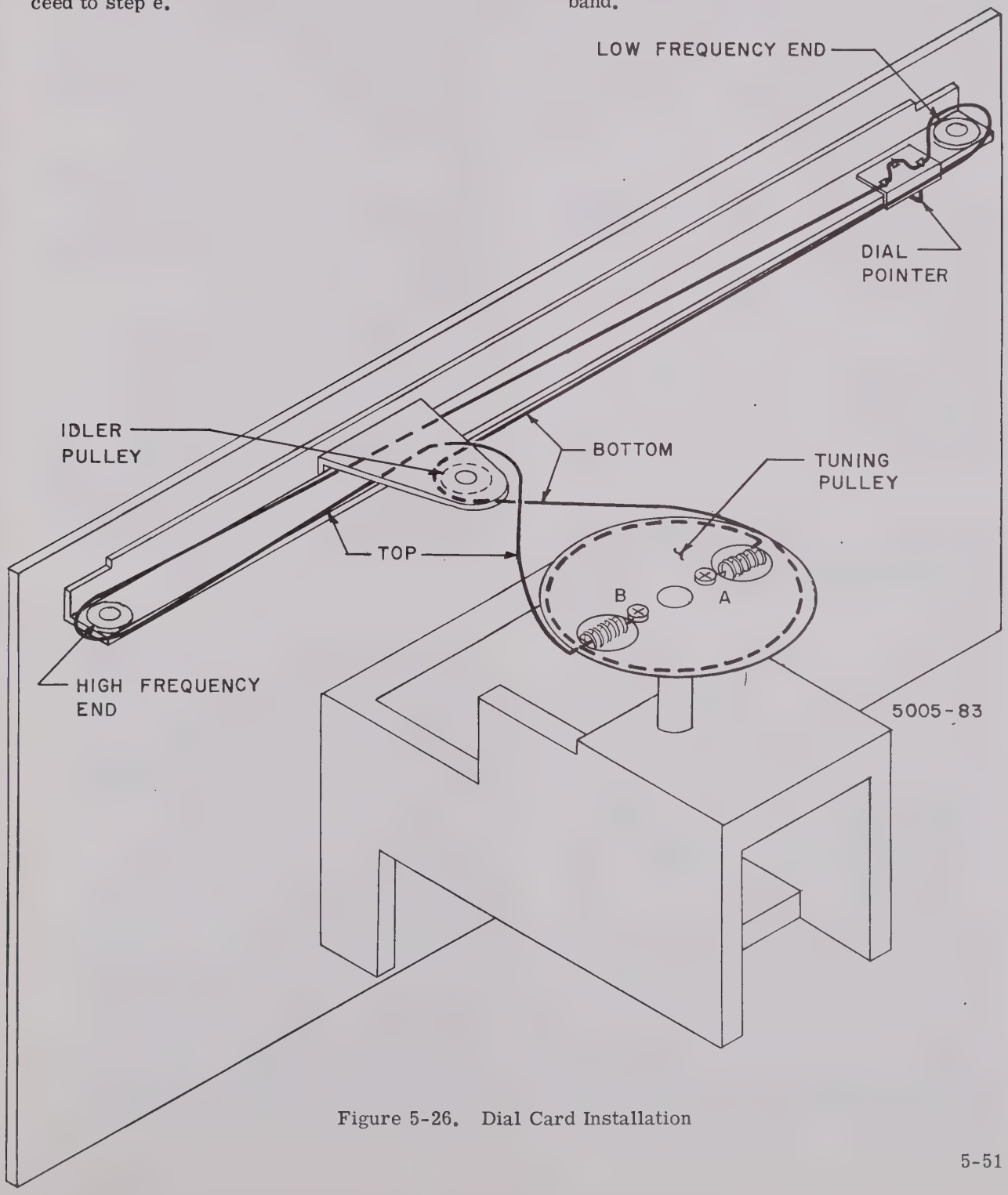


Figure 5-26. Dial Card Installation

5-93. ALIGNMENT.

5-94. Alignment procedures for components or circuits requiring special techniques are described in paragraphs 5-95 through 5-113.

5-95. IF/VIDEO CHASSIS ALIGNMENT. To align the IF/VIDEO chassis, set the operating controls to the positions listed in paragraph 5-63 and perform the following steps:

a. Remove the IF/VIDEO chassis from the analyzer in accordance with the removal procedures described in paragraph 5-47. Make sure that all cables remain properly connected.

b. Remove plug P601 and connect a crystal-controlled signal generator to receptacle J601 (8, figure 5-13). Inject a 75 MC signal at 50 microvolts.

NOTE

The signal input levels listed in this procedure are approximate. Sufficient signal amplitude and IF attenuation should be used throughout to maintain at 3/4 to full scale CRT signal with little or no noise appearing on the baseline.

c. Set the IF GAIN potentiometer R637 (20, figure 5-13) fully clockwise and the SWEEP WIDTH control approximately 3/4 clockwise; adjust oscillator inductor L609 (15, figure 5-13) for maximum baseline rise.

NOTE

Baseline rise is the term used to denote the reaction of the baseline to a signal injected following the swept oscillator. The entire baseline rises from its normal position at the lower edge of the screen graticule to some level proportional to signal amplitude. In step c. above, several peaks will be observed as the inductor is tuned; the highest peak is the correct setting.

d. Adjust the 75 MC inductors L601 (9, figure 5-13), L603 (12, figure 5-13), and L605 (14, figure 5-13).

e. Adjust coils Z601 (18, figure 5-13), Z603 (24, figure 5-13), Z605 (7, figure 5-13), and Z607 (5, figure 5-13) for maximum baseline rise using the hexagonal end of Walsco tool No. 2543.

NOTE

When initially aligning the IF transformer coils in step e. above, rotate the core slugs to their outermost limits (upper coil slugs fully counterclockwise, lower coil slugs fully clockwise). Beginning with coil Z601, adjust first the upper and then the lower slug for the first baseline peak. Repeat with coils Z603 through Z607.

f. Repeat steps c., d., and e. and to touch-up the adjustments. Disregard the NOTE following step e.

g. Disconnect the signal generator and insert plug P601 into receptacle J601. Disconnect plug P301 from receptacle J301 (22, figure 5-11). Connect a crystal-controlled signal generator to receptacle J301 and inject a precise 160 MC signal at approximately 500 millivolts.

h. Remove crystals CR601 (17, figure 5-13) and CR602 (11, figure 5-13).

i. Rotate the IF BANDWIDTH control fully clockwise and the SWEEP WIDTH control fully counterclockwise. Using the IF attenuator controls, adjust the CRT display for full scale deflection. Check that the signal bandwidth at the 3 db point (3 scale divisions below full scale) is a minimum of 140 KC ($6\frac{1}{2}$ horizontal scale divisions).

NOTE

When the SWEEP WIDTH control is fully counterclockwise, the sweep width is at minimum (i.e., 200 KC or ±100 KC about the center frequency). Accordingly, each graticule horizontal scale division represents 20 KC. To check the accuracy of the sweep width calibration, perform step i. of paragraph 5-97 (Wideband Oscillator Alignment).

NOTE

If the bandwidth of the signal pip is less than 140 KC, readjust coils Z601, Z603, Z605, and Z607. By trial, touch-up these IF transformers until the bandwidth is greater than 140 KC at the 3db points. While adjusting, maintain a symmetrical pip of the greatest possible amplitude (below full scale) and avoid shifting frequency by keeping the pip in the center of the CRT screen. Do not adjust the SPECTRUM CENTERING control. Coils should be tuned for exactly 160 MC.

j. Insert crystal CR601 and set the IF BANDWIDTH control to center travel.

k. Using Walsco tool No. 2451, adjust crystal nulling capacitor C627 (21, figure 5-13) for a symmetrical pip. The correct setting is the null which will be found between the two notched peaks.

l. Rotate the IF BANDWIDTH control fully clockwise and adjust crystal nulling inductor L611 (22, figure 5-13) for the broadest, nulled symmetrical pip.

m. Repeat steps k. and l. until optimum settings are obtained.

n. Remove crystal CR601 and insert crystal CR602. Set the IF BANDWIDTH control to center travel.

o. Using Walsco tool No. 2451, adjust crystal nulling capacitor C642 (27, figure 5-13) for a symmetrical pip. The correct setting is the null which will be found between the two notched peaks.

p. Rotate the IF BANDWIDTH control fully clockwise and adjust crystal nulling inductor L613 (29, figure 5-13) for the broadest, nulled symmetrical pip.

q. Repeat steps o. and p. until optimum settings are obtained.

NOTE

If a smooth curve is unobtainable because of a notch which cannot be tuned out, check that a 90 ohm, $\frac{1}{2}$ watt resistor (R368) is installed across inductor L620 and a 90 ohm, $\frac{1}{2}$ watt resistor (R625) is installed across inductor L608. If the installation of these two resistors does not completely remove the notch, center it on the signal pip. A small notch does not materially affect equipment performance.

r. Insert crystal CR601 and rotate the SWEEP WIDTH control fully counterclockwise (minimum sweep width).

s. Using the IF attenuator controls, adjust the signal for full scale deflection. Check that the signal bandwidth is a minimum of 70 KC ($3\frac{1}{2}$ horizontal scale divisions) at the 3 db points (three vertical scale divisions below full scale).

NOTE

If the signal bandwidth observed in step s. above is less than 70 MC, readjust coils Z601 through Z607.

t. Set the AMPLITUDE SCALE switch to the LOG position and the SWEEP WIDTH to center travel. Using the IF attenuator controls, adjust the signal for full scale deflection and check that all crystal spurious pips which may appear to the left of the signal pip are at least 40 db down.

NOTE

If the crystal spurious pips observed in step t. above are not at least 40 db down, readjust coils Z601 through Z607 and inductors L611 and L613.

u. Set the AMPLITUDE SCALE switch to the LIN position and rotate the SWEEP WIDTH control fully counterclockwise (minimum sweep width).

v. Using the IF attenuator controls, adjust the CRT display for full scale deflection and observe the signal pip. A properly aligned IF/VIDEO strip will produce a signal pip exhibiting the following characteristics.

(1) Good pip symmetry
(2) 70 KC bandwidth at 3 db points
(3) With the AMPLITUDE SCALE switch in the LOG position, all crystal spurious pips are at least 40 db down.
(4) The center of the signal pip does not shift horizontally when the IF BANDWIDTH control is rotated through full travel.

NOTE

To obtain proper alignment, it is usually necessary at this point to touch up the adjustments to coils Z601, Z603, and Z607 and inductors L611 and L613. If the required performance cannot be obtained, repeat steps g through v.

5-96. AMPLITUDE SCALE SWITCH CIRCUIT ALIGNMENT. To align the AMPLITUDE SCALE switch circuit, set the operating controls to the positions indicated in paragraph 5-63 and perform the following steps:

a. Adjust the V POS adjusting screw so that the lower edge of the baseline just touches the bottom line on the CRT screen graticule.

b. Connect a step attenuator in series between the output terminal of a crystal controlled signal generator and receptacle J301 (22, figure 5-11). Set the step attenuator for 20 db of attenuation.

c. Inject a 160 MC signal and adjust the signal generator output to provide a full scale display on the CRT. Adjust the SPECTRUM CENTERING control to place the signal pip at the left side of the screen near the LOG calibration dots.

d. Set the AMPLITUDE SCALE switch to the LOG position and adjust the LOG 20 DB potentiometer R650 (25, figure 5-13) to set the signal amplitude to the -20 DB point on the CRT screen.

e. Switch out the 20 db external attenuation and adjust the LOG 0 ADJ potentiometer R659 (4, figure 5-13) to set the signal amplitude to full scale on the CRT screen.

f. Repeat steps b. through e. until no further adjustment is required.

g. Rotate the IF BANDWIDTH control fully clockwise and set the AMPLITUDE SCALE switch to the PWR position. Adjust the signal generator output level for a full scale display on the CRT screen.

NOTE

If oscillations break out on the top of the full scale pip when the AMPLITUDE SCALE switch is set to the PWR position, adjust the last VIDEO/IF coil Z607 (5, figure 5-13) until oscillations are suppressed while maintaining good signal symmetry.

h. Set the step attenuator for 3 db of attenuation and adjust the PWR ADJ potentiometer R657 (6, figure 5-13) for half scale deflection.

i. Switch out the 3 db of external attenuation and set all six of the analyzer IF ATTENUATOR switches to the IN (up) position. Set the AMPLITUDE SCALE switch to the LIN position and adjust the signal generator output level for a full scale display on the CRT screen.

j. Adjust the step attenuator for 20 db of external attenuation and set the analyzer IF ATTENUATOR 20 DB switch to the down (out) position. Check that the signal amplitude is within $\pm\frac{1}{2}$ vertical scale division of full scale.

k. Insert an additional 10 db of external attenuation and set the analyzer IF ATTENUATOR 10 DB switch to the down position. Again check that the signal amplitude is within $\pm\frac{1}{2}$ scale division of full scale.

l. Repeat the procedure described in steps j. and k. above to check the 5 DB, 2 DB, 2 DB, and 1 DB IF ATTENUATOR switch circuits.

NOTE

If the signal variation for any attenuator circuit varies more than $\pm\frac{1}{2}$ scale division, perform the following steps:

(1) Set the IF BANDWIDTH control to center travel and adjust the signal generator output for a full scale signal.
(2) Peak inductors L601 (9, figure 5-13), L338 (35, figure 5-11), and L340 (34, figure 5-11) for maximum signal amplitude.
(3) Repeat steps i. through l. until no further adjustment is required.

m. Remove the signal generator lead from receptacle J301 (22, figure 5-11) and reconnect plug P301.

5-97. WIDEBAND OSCILLATOR ALIGNMENT. To align the wideband oscillator, set the operating controls to the positions indicated in paragraph 5-63 and perform the following steps:

a. Set the CF LIN potentiometer R347 (29, figure 5-11) and the coarse spectrum centering potentiometer R367 (11, figure 5-15) to center travel. Check that the spectrum centering control is also centered.

b. Using a BNC "T" adapter, connect the output leads from a signal generator and a crystal calibrator to receptacle J301 (22, figure 5-11). Inject a precise 160 MC signal from the generator and 10 MC market pips from the calibrator. Adjust the signal generator tuning as required to superimpose the signal pip on the nearest marker pip.

c. Adjust capacitor C361 (40, figure 5-11) as required to center the 160 MC pip on the CRT screen.

NOTE

When adjusting capacitor C361, favor the setting which provides maximum capacity (i.e. a slight signal drift to the left). This setting provides best compensation for reliable operation under heat.

NOTE

If the marker pips on the right hand side of the screen disappear, return capacitor C361 to a setting where the missing pips return. Alternate between adjustments of capacitor C361 and the coarse spectrum centering potentiometer R367 until 9 pips are displayed on the screen (four on each side of the center 160 MC pip).

d. Adjust the CF LIN potentiometer R347 (29, figure 5-11) for best symmetry and linearity of the marker pips. If the 160 MC signal pip is displaced from the center of the screen, repeat step c.

e. Rotate the SWEEP WIDTH control fully counterclockwise (minimum sweep width) and readjust capacitor C361 (40, figure 5-11) to center the 160 MC signal pip.

f. Rotate the SWEEP WIDTH control fully clockwise and adjust the H POS adjusting screw to center the 160 MC signal pip.

g. Adjust the 80 MC ADJ potentiometer R865 (16, figure 5-11) for an 80 MC dispersion (one marker pip in center and four on either side).

h. Disconnect the crystal calibrator and connect an audio oscillator to the external modulation input receptacle of the signal generator. Modulate the signal generator output at 100 KC.

i. Rotate the SWEEP WIDTH control fully counterclockwise and resolve the signal pips using the IF BANDWIDTH control until the signal peaks are sharply displayed. Adjust the 200 KC ADJ potentiometer R861 (18, figure 5-11) for a 200 KC dispersion (sideband pips centered on graticule extremities). Disconnect the audio oscillator.

j. Rotate the SWEEP WIDTH control fully counterclockwise and set the TUNING control below 95 MC. (Check for audible click in Tuning Head indicating analyzer has switched to narrow band.) Reconnect the crystal calibrator and inject 1 MC marker pips. Adjust the 5 MC ADJ potentiometer R871 (20, figure 5-11) for a 5 MC dispersion (two marker pips on either side of center pip). Disconnect the crystal calibrator.

k. Reconnect the audio oscillator and modulate the signal generator at 100 KC. Rotate the SWEEP WIDTH control fully counterclockwise. Resolve the signal pips using the IF BANDWIDTH control and adjust the 200 KC LOW potentiometer R867 (17, figure 5-11) for a 200 KC dispersion.

5-98. KLYSTRON CAVITY ALIGNMENT. Before attempting to align the klystron the operator should become familiar with the descriptive data contained in the following paragraphs. In addition, it will be necessary to construct a klystron mode modulator. The necessary components and the required connections for this device are shown in figure 5-27 and may be made locally or purchased from The Singer Company, Metrics Division.

5-99. The oscilloscope waveform shown in figure 5-28a illustrates a typical example of the desired klystron mode. This waveform represents the end result of the alignment procedure. Note that the amplitude of the display above the baseline represents the klystron power output at the selected frequency. The lobe should be well-centered on the oscilloscope screen and delivering its maximum power at the desired frequency with the dip caused by the monitoring wavemeter located at the peak of the mode.

5-100. The waveform shown in figure 5-28a illustrates a "normal" mode. At times it may appear much lower in amplitude because of a mismatch somewhere in the signal path. If the mismatch is extreme, the detected signal may disappear entirely. As arule of thumb, any detected signal output above 1 millivolt seen on the oscilloscope may be considered passable. A signal level below 1 millivolt will not supply sufficient conversion power to provide adequate RF signal sensitivity for normal operation.

5-101. The oscilloscope display shown in figure 5-28b illustrates the presentation produced when a large modulation voltage is applied. Note that several modes appear on the screen at once. This feature enables the operator to locate the proper mode more easily.

NOTE

The 6BL6 klystron used by the Model SPA-10 uses the 2-3/4 mode. For repeller mode characteristics see figure 5-29.

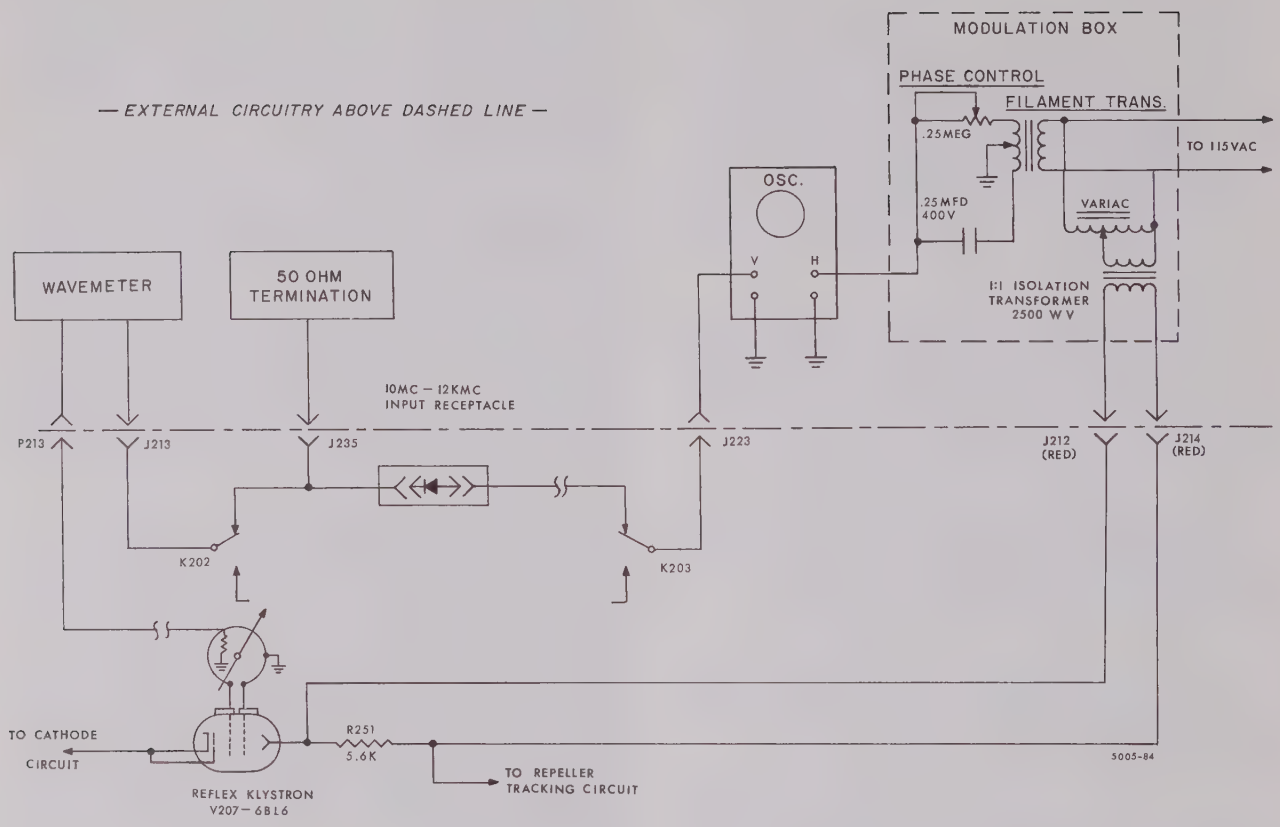


Figure 5-27. Klystron Mode Modulator

5-102. Figure 5-28c illustrates the oscilloscope presentation when spurious side modes appear to be part of the true mode. They may be differentiated from the true mode by tracking the wavemeter pip through the modes. The pip will disappear at the extremeties of the true mode and will not follow through to the spurious modes.

5-103. These spurious modes may be several hundred megacycles away from the true mode so that in operation they will not be objectionable because of the IF rejection factor. As a result, no spurious signals will appear near the true signals because of spurious klystron modes.

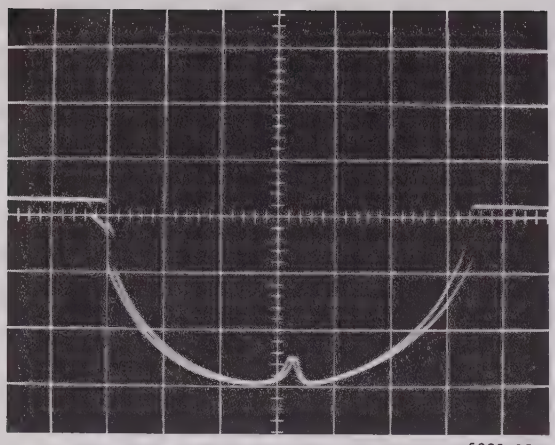
5-104. The display shown in figure 5-28d illustrates an uncentered klystron mode. Adjustment of the OSC ADJ potentiometers R255 and R259 should be made to center the mode.

5-105. Figure 5-28e shows the screen presentation produced by an open circuit in the test setup shown in figure 5-27. The most common causes of this indication are: broken resistors in the cavity probes, open grounds anywhere in the circuit, or poor contact in any of the relays.

5-106. To align the klystron, set the operating controls to the positions listed in paragraph 5-63 except set the POWER SCALE ILLUM switch to the OFF position and perform the following steps:

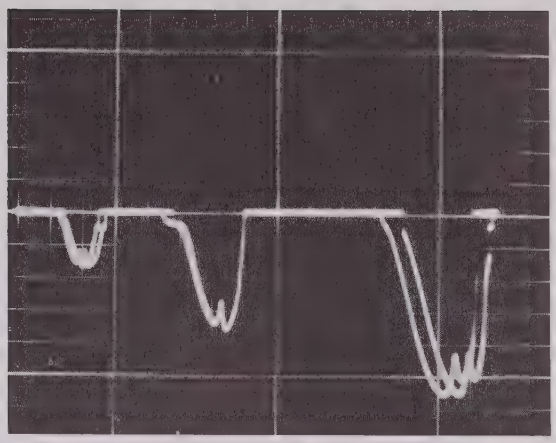
a. Set the TUNING control fully counterclockwise and check that the cam follower is just beyond cam adjusting screw No. 4 (8, figure 5-23).

b. Rotate the TUNING control fully clockwise and check that the cam follower (6, figure 5-23) is just beyond cam adjusting screw No. 4 (8, figure 5-23).



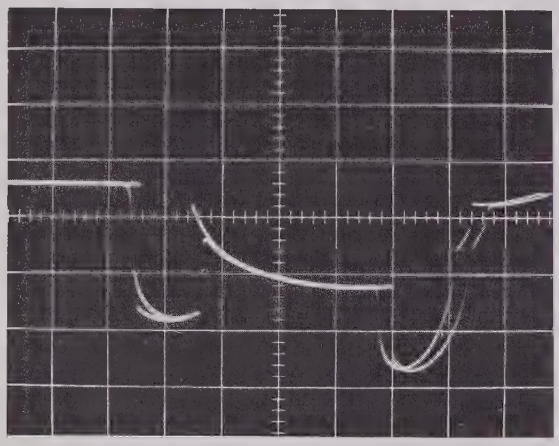
5005-85

a.



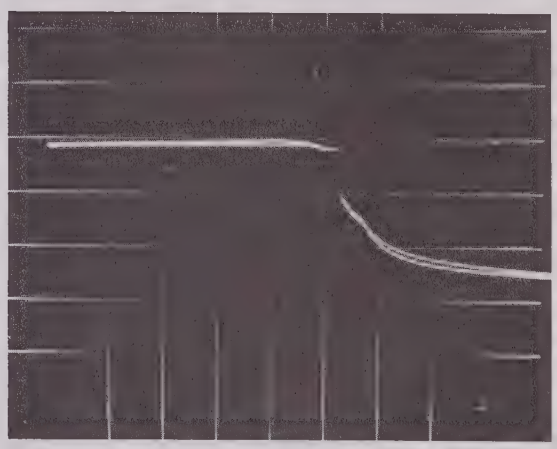
5005-86

b.



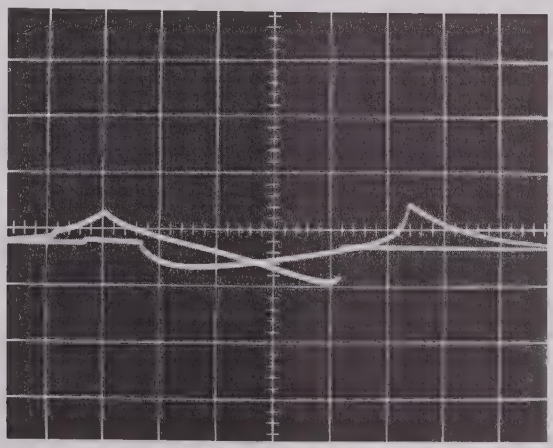
5005-87

c.



5005-88

d.



5005-89

e.

Figure 5-28. Klystron Modes

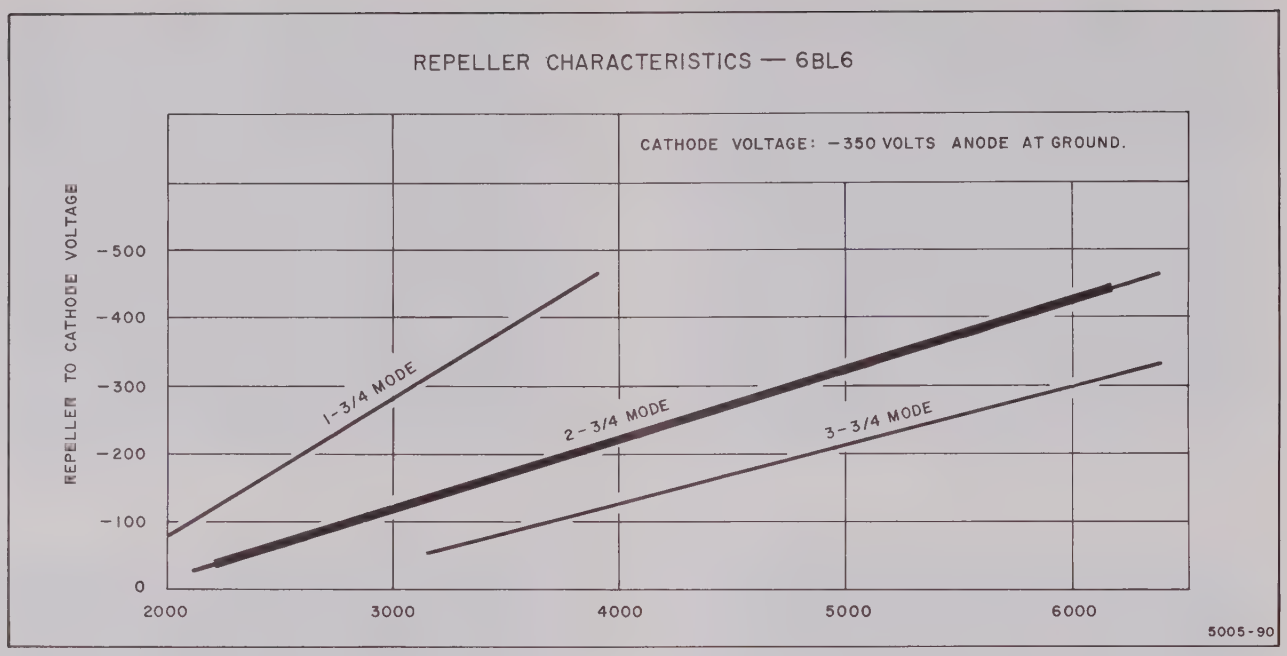


Figure 5-29. Repeller Mode Characteristics — 6BL6 Klystron

NOTE

If cam travel requires readjustment to comply with steps a. and b., loosen the two screws securing the shaft collar (3, figure 5-23) and adjust cam rotation as required. Retighten the collar screws.

c. Rotate the TUNING control fully counterclockwise. Using a multimeter, measure the resistance between the wiper and the low end of tracking potentiometer R257 (1, figure 5-23). This resistance should be approximately 3.6 K ohms.

d. Rotate the TUNING control fully clockwise. Using a multimeter, measure the resistance between the wiper and the high end of tracking potentiometer R257. This resistance should be approximately 3.6 K ohms.

NOTE

If the resistances obtained in steps c. and d. are unequal, loosen the retaining collar and adjust tracking potentiometer R257 to provide equal readings. Secure the collar.

e. Rotate the POWER SCALE ILLUM switch clockwise to turn on the analyzer and set the RANGE switch to the 3-12 KMC position. Set the INTERNAL CHECK switch to the KLYSTRON CUR and ANODE V positions and compare the indications on the internal check meter with the corresponding data listed in table 5-3.

f. Set the RANGE switch to the 10MC-3KMC position (disconnecting the high voltage from the klystron circuit) and remove the cover from the klystron disconnect plug. Using a multimeter, check the klystron filament voltage at pins 1 and 2. This voltage should be 6.3 VDC. Replace the plug cover and return the RANGE switch to the 3-12 KMC position.

g. Connect a multimeter to the red jack J212 (4, figure 5-18) and the white jack J210 (3, figure 5-18) on the potentiometer board. Note that jack J212 is the negative terminal.

h. Rotate the TUNING control fully counterclockwise and adjust the LO potentiometer R255 (5, figure 5-18) for a 50 VDC indication on the multimeter.

i. Rotate the TUNING control fully clockwise and adjust the HI potentiometer R259 (2, figure 5-18) for a 500 VDC indication on the multimeter.

j. Repeat steps h. and i. until no further adjustment is required.

k. Disconnect the multimeter and connect a klystron modulation box in accordance with figure 5-27. Note that the klystron repeller leads should be connected to jacks J212 (4, figure 5-18) and J214 (1, figure 5-18) on the potentiometer board.

l. Connect a 50 ohm termination to the 10MC-12KMC INPUT receptacle.

m. Disconnect the output of relay K203 at plug P223 (6, figure 5-20). Connect the Y axis of an oscilloscope to receptacle J223 and set the oscilloscope vertical input mode control to DC operation. Connect the X axis input as shown in figure 5-27.

n. Set the Variac for zero volts and adjust the oscilloscope horizontal controls for a full trace centered vertically on the screen. Increase the Variac output to approximately 20 volts and adjust the phase controls to superimpose the forward and reverse traces on the screen. Increase the modulation (Variac output) to approximately 60 volts and note that three klystron repeller modes appear on the screen.

o. Disconnect the klystron output cable at plug P213 (12, figure 5-23) and connect the plug to the input receptacle of a wavemeter. Connect the wavemeter output receptacle to receptacle J213.

p. Locate the 2-3/4 klystron mode by setting the TUNING control to 3650 MC and the wavemeter to 3810 MC (3650 MC + 160 MC). The proper mode may be identified by tuning the wavemeter until the signal pip appears on the mode. Disconnect the wavemeter and reconnect plug P213 to receptacle J213.

q. Reduce the modulation voltage (Variac output) until only the 2-3/4 mode is present on the oscilloscope screen.

r. Rotate the TUNING control to the low end of the dial (2.2 KMC) and adjust the modulating voltage, the oscilloscope controls, and the LOW potentiometer R255 (5, figure 5-18) so that the mode is centered about the center line of the oscilloscope screen.

s. Rotate the TUNING control to the high end of the dial (6.1 KMC) and adjust the modulating voltage, the oscilloscope controls, and the HIGH potentiometer R259 (2, figure 5-18) so that the mode is centered about the center line of the oscilloscope screen.

t. Repeat steps r. and s. until no further adjustment is required. To check, slowly rotate the TUNING control counterclockwise and note that the mode remains centered throughout its entire range.

NOTE

It will be necessary to alternate between the HIGH and LOW potentiometer adjustments to establish settings which will present a well-centered mode producing adequate power across the entire tuning band. Do not proceed until this is accomplished.

u. Disconnect the klystron output cable at plug P213 (12, figure 5-23) and connect the plug to the input receptacle of a wavemeter. Connect the wavemeter output receptacle to receptacle J213.

NOTE

The wavemeter must be changed during the following steps as the frequencies under test exceed the range of the instrument installed.

v. Set the TUNING control to 3650 MC and the wavemeter to 3810 MC (3650 MC +160 MC). Observe the oscilloscope and rotate the center position adjusting screw (7, figure 5-18) as required to center the wavemeter pip on the mode display curve.

w. Set the TUNING control to 3100 MC and the wavemeter to 3260 MC. Observe the oscilloscope and rotate cam adjusting screw No. 4 (8, figure 5-23) as required to center the wavemeter pip on the mode display curve.

NOTE

A 3/32 inch hexagonal wrench is required to adjust the cam screws.

x. Set the TUNING control to 2650 MC and the wavemeter to 2810 MC. Observe the oscilloscope and rotate cam adjusting screw No. 5 (7, figure 5-23) as required to center the wavemeter pip on the mode display curve.

y. Set the TUNING control to 2200 MC and the wavemeter to 2360 MC. Observe the oscilloscope and rotate cam adjusting screw No. 6 (4, figure 5-23) as required to center the wavemeter pip on the mode display curve.

z. Set the TUNING control to 4300 MC and the wavemeter to 4460 MC. Observe the oscilloscope and rotate cam adjusting screw No. 3 (5, figure 5-23) as required to center the wavemeter pip on the mode display curve.

aa. Set the TUNING control to 5150 MC and the wavemeter to 5310 MC. Observe the oscilloscope and rotate cam adjusting screw No. 2 (15, figure 5-23) as required to center the wavemeter pip on the mode display curve.

bb. Set the TUNING control to 6000 MC and the wavemeter to 6160 MC. Observe the oscilloscope and rotate cam adjusting screw No. 1 (13, figure 5-23) as required to center the wavemeter pip on the mode display curve.

cc. Slowly rotate the TUNING control from fully counterclockwise to fully clockwise and adjust the HI and LO potentiometers R259 (2, figure 5-18) and R255 (5, figure 5-18) to keep the mode display curve centered on the oscilloscope screen.

dd. Repeat steps v. through bb. and touch up adjustments.

ee. Apply glyptol to all cam adjusting screws and disconnect the modulating equipment.

5-107. .160 MC NARROW BAND FILTER ALIGNMENT. To align the 160 MC narrow band filter, set the POWER SCALE ILLUM switch to the OFF position and disconnect plugs P253 and P245. Connect the filter into the test setup shown in figure 5-30 using 90 ohm cable and perform the following steps:

a. Set the Kay attenuator for a minimum of 20 db of attenuation and adjust the sweep generator, marker pips, and oscilloscope controls to display a 160±5 MC response curve similar to that shown in figure 5-31.

NOTE

If one or more filter coils have been replaced or if severe deterioration of the response curve is noted, perform step b. Usually, however, only a touch-up alignment is required, beginning with step c.

b. Unscrew the four retaining screws and remove the filter from the Tuning Head. Remove the filter cover and perform the following procedure:

1. Spread the coils of two-turn inductors L241, L239, and L237 to their widest position.

2. Squeeze the coils of two-turn inductors L249 and L245 as close together as possible with the inductive link between the turns acting as a spacer.

3. Spread the coils of two-turn inductor L247 to their widest position.

4. Rotate the tuning slugs of inductors L241, L239, and L237 to their maximum outward position.

5. Rotate the tuning slugs of inductors L249, L245, and L247 to the midpoint of their travel.

6. Replace the filter cover and replace the filter in the Tuning Head.

c. Adjust inductors L249, L247, L245, L241, L239, and L237 as required to obtain the desired response curve shown in figure 5-31. Note that the curve should be flat (above 3 db point) to ±2.5 MC around 160 MC.

NOTE

In general, inductors L249, L247, and L245 tune the band rejection portion of the filter response and will affect the skirt selectivity. Inductors L241, L239, and L237 tune the band pass portion of the filter and will affect the flatness of the response curve. When the filter has been properly aligned, the insertion loss is from 1 to 3 db.

d. When the filter has been aligned, remove the filter from the test setup and reconnect plugs P253 and P245. Replace the filter cover and secure the four retaining screws.

5-108. .75 MC FILTER ALIGNMENT. To align the 75 MC filter, set the POWER SCALE ILLUM switch to the OFF position and disconnect plugs P304 and P306. Connect the filter into the test setup shown in figure 5-30 using 90 ohm cable and perform the following steps:

a. Set the Kay attenuator for a minimum of 20 db of attenuation and adjust the sweep

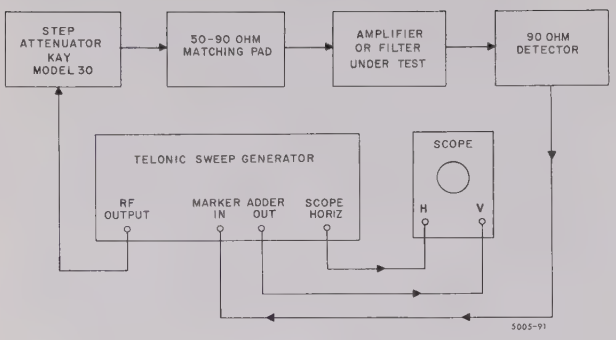


Figure 5-30. Amplifier/Filter Test Set-up

generator, marker pips, and oscilloscope controls to display a 75±3 MC response curve similar to that shown in figure 5-32.

NOTE

If one or more filter coils have been replaced or if severe deterioration of the response curve is noted, perform step b. Usually, however, only a touch-up alignment is required, beginning with step c.

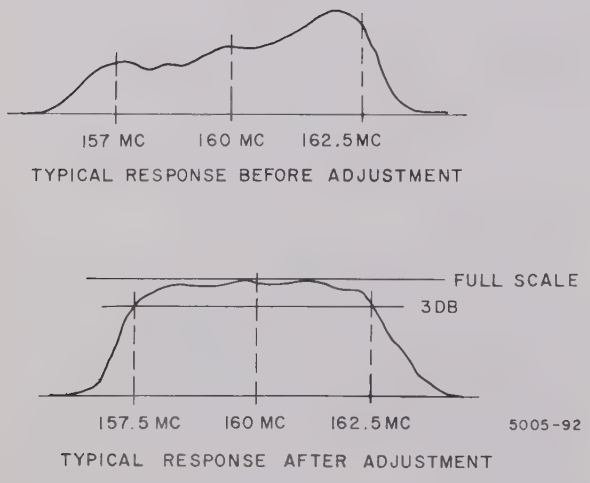


Figure 5-31. 160 MC Narrow Band Filter Response Curve

b. Remove the center retaining screw and remove the filter cover. Rotate the tuning slugs on inductors L338 and L340 about half way out of their forms. Spread or compress the coils of these inductors as required until the filter response approaches that of figure 5-32. Replace the filter cover and retaining screw.

c. Adjust the tuning slugs of inductors L338 and L340 as required to obtain the response curve shown in figure 5-32. Note that the curve should be flat (above the 3 db point) to ±1.5 MC around 75 MC.

d. Disconnect the filter from the test setup and reconnect plugs P304 and P306.

5-109. .160 MC PREAMPLIFIER ALIGNMENT. To align the 160 MC preamplifier, set the operating controls to the positions indicated in paragraph 5-63 and perform the following steps:

NOTE

Check that the TUNING control is set above 100 MC to ensure that the Tuning Head is in the wideband mode and allow a 30 minute warmup to permit component values to stabilize. Other control settings are not critical for this procedure.

a. Set up the test equipment as shown in figure 5-30 except delete the 50-90 ohm matching pad.

b. Disconnect plug P233 (6, figure 5-20) from relay K203 (7, figure 5-20) and connect

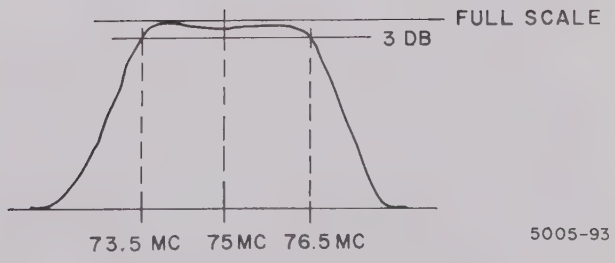


Figure 5-32. 75 MC Filter Response Curve

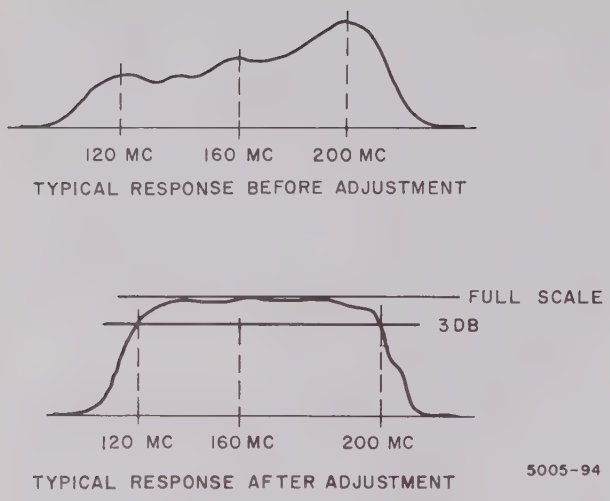


Figure 5-33. 160 MC Amplifier Response Curve

the plug to the output of the Kay attenuator using 50 ohm cable. Disconnect plug P255 from receptacle J255 (1, figure 5-19) and connect the receptacle to the 90 ohm detector in the test setup using 90 ohm cable.

c. Set the Kay attenuator for a minimum of 20 db of attenuation and adjust the sweep generator, marker pips, and oscilloscope controls to display a 160±60 MC response curve similar to that shown in figure 5-33.

NOTE

If one or more coils or capacitors have been replaced or if severe deterioration of the response curve is noted, perform step d. Usually, however, only a touch-up alignment is required, beginning with step e.

d. Set the POWER SCALE ILLUM switch to the OFF position and perform the following procedure:

1. Remove the 4 retaining screws and pull the preamplifier chassis clear.

2. Remove the 9 retaining screws and remove the preamplifier cover.

3. Rotate the POWER SCALE ILLUM switch clockwise to apply analyzer power and allow a 5 minute warmup.

4. Adjust trimmer capacitors C227 (11, figure 5-19), C237 (12, figure 5-19), C241 (13, figure 5-19), C253 (10, figure 5-19), and C259 (9, figure 5-19) to the mid-point of their travel.

5. Alternately spread and compress the coils of the preamplifier inductors and note which inductors affect the high frequencies, low frequencies, and total bandpass.

6. Adjust the preamplifier coils for a response curve approaching that of figure 5-33.

7. Set the POWER SCALE ILLUM switch to the OFF position; replace the preamplifier cover and retaining screws and mount the chassis on the Tuning Head.

8. Rotate the POWER SCALE ILLUM switch clockwise to reapply analyzer power and allow a 5 minute warmup.

e. Adjust trimmer capacitors C227, C237, C241, C253, and C259 as required to obtain the desired response curve shown in figure 5-33. Note that the curve should be flat (above 3 db) to ±40 MC about 160 MC. When the preamplifier has been properly aligned it should provide an approximate gain of 15 db for the indicated bandpass.

5-110. TRIODE OSCILLATOR ALIGNMENT. To align the triode oscillator, set the operating controls to the positions indicated in paragraph 5-63 and perform the following steps:

a. Using a VTVM, measure the triode oscillator plate voltage at the B+ feed-thru (3, figure 5-20) and the filament voltage at the filament voltage feed-thru (4, figure 5-20). The plate voltage should be 80 to 90 volts; the filament voltage should be 6.3 VDC.

b. Set the TUNING control to 700 MC and adjust the SWEEP WIDTH control for an 80 MC sweep using the marker pip.

NOTE

When tuning to adjust the frequency, always begin with the pointer at the right hand side of the dial and tune to the left. This practice will reduce tuner backlash.

c. Connect a crystal-controlled signal generator and a pad to the 10 MC-12 KMC INPUT receptacle and inject a precise 700 MC signal. Check that the signal pip appears at the exact center of the CRT graticule.

NOTE

If the signal pip appears centered, reduce the sweep width to approximately 1 MC and check that the signal pip is still centered. If it is centered, proceed to step i.; if not, continue with step d.

d. If the signal is not centered, remove the triode oscillator cover and loosen the oscillator arm retaining screw. Adjust the arm along its track as required to center the signal pip. Gently tighten the retaining screw.

e. Replace the oscillator cover and hand tighten the cover screws. Note the amount and direction of signal shift away from the screen center.

f. Remove the oscillator cover and loosen the oscillator arm retaining screw. Adjust the oscillator arm to shift the signal by an equal amount but in the opposite direction to the shift observed in step e. Gently tighten the arm retaining screw.

g. Repeat steps e. and f. until the 700 MC signal is centered when the oscillator cover is secured in place. Check the centering by progressively narrowing the sweep width to about 1 MC.

h. Tighten the oscillator arm and panel cover screws securely.

CAUTION

Use care in tightening the arm retaining screw to avoid stripping the phenolic threads in the oscillator arm.

i. Tune the analyzer and signal generator downward concurrently from 700 MC to 10 MC and check for "dead spots" (i.e. points at which the signal disappears).

NOTE

If "dead spots" are observed, check the tension on the brush springs. If the spring tension is sufficient to maintain positive contact throughout full arm travel, lightly sand both the track and brush surfaces to remove any surface coating which may prevent good contact.

j. If no "dead spots" are observed, tune the analyzer and signal generator to 400 MC. Insert a Walsco No. 2251 tool straight into the hole at the side of the triode oscillator cover and adjust trimmer capacitor C209 (1, figure 5-21) to position the signal pip at the center of the screen. Begin with an 80 MC sweep width and gradually reduce the sweep width while keeping the pip centered.

k. Tune the analyzer and signal generator to 150 MC. Insert a Walsco No. 2551 tool (down and to the right) through the hole at the side of the triode oscillator cover and adjust trimmer capacitor C207 (2, figure 5-21) to position the signal pip at the center of the screen while reducing sweep width from 80 MC.

l. Repeat steps j. and k. until no further adjustment is required.

m. Tune the analyzer and signal generator to 50 MC. Insert a Walsco No. 2551 tool (upward and near the edge) through the hole at the bottom of the triode oscillator cover and adjust trimmer capacitor C205 (1, figure 5-22) to position the signal pip at the center of the screen while reducing the sweep width from 80 MC.

n. Tune the analyzer and signal generator to 10 MC. Insert a Walsco No. 2551 tool straight through and deep into the hole at the bottom of the triode oscillator cover and adjust trimmer capacitor C203 (2, figure 5-22) to position the signal pip at the center of the screen while reducing the sweep width from 80 MC.

o. Repeat steps j. through n. as required until the analyzer tracks with the signal generator output from 10 MC to 700 MC within ±1% or 1 MC, whichever is greater. Accordingly, the permissible frequency error varies from 1 MC to 7 MC through the tuning range.

NOTE

If "dead spots" appear at any time in this procedure, turn all four trimmer capacitors fully counterclockwise and return to step a.

5-111. MARKER OSCILLATOR ALIGNMENT. The marker oscillator should be realigned following the replacement of tube V401 or whenever marker accuracy is in doubt. To align the marker oscillator set the operating controls to the positions listed in paragraph 5-63 and perform the following steps:

a. Disconnect plug P301 and connect a crystal calibrator to receptacle J301 (22, figure 5-11). Adjust the calibrator to provide 10 MC marker pips.

b. Adjust the SPECTRUM CENTERING control so that 9 pips are displayed on the CRT screen with the center pip coinciding with the -0+ screen calibration.

NOTE

With the SWEEP WIDTH control fully clockwise, the CRT screen displays a dispersion of 80 MC. The center pip represents the 160 MC IF center frequency and the extreme left and right hand pips represent the 120 MC and 200 MC (160 ±40 MC) maximum IF bandwidth limits respectively.

c. Adjust the MARKER LEVEL control for a full scale marker pip.

d. Rotate the SWEEP WIDTH control fully counterclockwise and adjust the MARKER FREQUENCY control until the marker pip coincides exactly with the 160 MC crystal marker at the center of the CRT screen. Check that the 0 MC calibration on the MARKER dial is aligned with the window crosshair.

NOTE

If the 0 MC calibration is not aligned with the crosshair, hold the MARKER FREQUENCY control so that the marker pip is aligned with the 160 MC crystal marker. Using a No. 6 six-fluted Bristol spline wrench, carefully loosen the two set screws securing the tuning gear to the nylon shaft. Rotate the dial plate until the 0 MC mark is aligned with the crosshair and retighten the setscrews.

e. Rotate the SWEEP WIDTH control fully clockwise and rotate the MARKER FREQUENCY control clockwise to -40 MC. Adjust capacitors C403 (4, figure 5-11) and C405 (2, figure 5-11) equally and simultaneously until the marker pip is aligned with the 120 MC crystal calibrator pip.

f. Set the MARKER FREQUENCY control counterclockwise to +40 MC and adjust inductor L407 (3, figure 5-11) until the marker pip is aligned with the 200 MC crystal calibrator pip.

g. Repeat steps e. and f. until no further adjustment is required.

h. Repeat step d. If the crystal calibrator and marker pips are not aligned, readjust the dial plate and repeat steps e. through g.

i. When the +40, 0, and -40 MC dial calibrations have been satisfactorily established, check the MARKER dial calibrations at 10 MC intervals using the crystal marker pips as a reference. The 0 MC calibration should align exactly; the other points should be within ±5%. If not, repeat steps d. through h.

j. Disconnect the crystal calibrator and reconnect plug P301 to receptacle J301.

5-112. FM BUCKING ADJUSTMENT. To minimize the effects of internal FM produced within the analyzer, set the operating controls to the positions listed in paragraph 5-63 and perform the following steps.

a. Adjust the MARKER LEVEL control for a full scale marker pip. Rotate the SWEEP WIDTH control fully counterclockwise and adjust the SPECTRUM CENTERING control as required to center the marker pip.

b. Set the CAL SYNC SEL switch to the EXT position and rotate the SYNC AMPL control fully counterclockwise. Adjust the IF BANDWIDTH control for optimum resolution.

c. Adjust the FM BUCK potentiometer R346 (38, figure 5-11) for minimum signal pip jitter. Tighten the potentiometer locking nut to maintain the proper setting.

5-113. FINAL FLATNESS ADJUSTMENT. This adjustment is the final analyzer alignment procedure and should be performed only after all circuits have been individually aligned and flattened. In this procedure, the analyzer is adjusted to present a CRT response curve which is flat within ±1.5 db in the wideband mode and ±0.75 db in the narrow band mode. Careful alignment can often produce a response which is substantially better than the minimum specifications. To adjust for final flatness, perform the following steps:

a. Set the operating controls to the position listed in paragraph 5-63 and set up the test equipment as shown in figure 5-30.

NOTE

When connecting cables to any chassis plug, insert a 10 db pad to ensure proper matching.

b. Disconnect plug P301 and connect the sweep generator to receptacle J301 (22, figure 5-11). Adjust the sweep generator for an output of ±50 MC about 160 MC.

c. Adjust the SWEEP WIDTH control for an 80 MC dispersion and set the sweep generator output for a full scale display.

d. Set the SWEEP RATE control for a slow sweep rate and adjust the IF BANDWIDTH control until the series of signal peaks displayed across the screen are well defined.

e. Adjust capacitor C303 (23, figure 5-11) and inductor L331 for maximum flatness (equal pip height across the screen).

f. Disconnect the sweep generator and reconnect plug P301 to receptacle J301.

g. Disconnect plug P223 (6, figure 5-20) and connect the sweep generator to receptacle J223. Inject a swept signal of ±50MC about 160 MC. Adjust the IF BANDWIDTH control until the signal pips are sharply defined.

h. Adjust capacitors C227 (11, figure 5-19) and C259 (9, figure 5-19) for maximum flatness (equal pip height across the screen). Disconnect the sweep generator and reconnect plug P223 to receptacle J223.

i. Connect the sweep generator to the 10 MC – 12 KMC INPUT receptacle. Set the TUNING control to 700 MC and adjust capacitor C217 for maximum flatness of this unconverted signal.

NOTE

If the crystal diode or capacitor C217 have been replaced, it may be necessary to squeeze or spread the coils of inductors L205, L207 and L209 until a flat response is achieved.

j. Adjust the sweep generator output to ±50 MC about 300 MC and set the TUNING control to 300 MC. Adjust capacitor C217 for maximum flatness of this converted signal.

k. Set the TUNING control to 50 MC to put the analyzer in the narrow band mode and adjust the sweep generator output to ±3 MC about 50 MC. Adjust inductors L241 (16, figure 5-19), L239 (15, figure 5-19), and L237 (12, figure 5-19) for a minimum flatness of ±0.75 db on the CRT screen.

5-114. CRYSTAL CALIBRATOR MAINTENANCE.

5-115. The optional crystal calibrator has been designed for stable, trouble-free operation and should not require frequent attention. Nevertheless, variation in component value due to aging may cause some degradation of calibrator performance. If this occurs, the calibrator should be realigned in accordance with the following procedures. Failure of the calibrator to respond properly to realignment indicates a component failure. In this event, trouble-shoot the calibrator using the voltage and resistance data listed in Table 5-7.

5-116. CALIBRATOR ALIGNMENT.

5-117. EQUIPMENT REQUIRED. The following equipment (or equivalents thereof) required to align the crystal calibrator unit is listed in the following tabulation:

Nomenclature	Specifications	Manufacturer
Attenuator	0-20 db (minimum)	Kay, Model 30
Frequency Counter	1-100 MC range (minimum)	Hewlett-Packard Model 524 D
Power Supply	250 VDC @60 MA & 6.3 VAC @2 amperes	Lambda Electronics, Model 25
Power Meter	0-10 MW capacity	The Singer Co., Metrics Division, Model 9301
Thermistor Mount	10 MW capacity (minimum)	The Singer Co., Metrics Division, Model AB-103
Milliammeter	0-60 MA (minimum)	(Standard)

NOTE

It is recommended that the calibrator be removed from the Tuning Head for troubleshooting and initial alignment. Final touch-up procedures may be performed after the unit has been reinstalled.

5-118. 1 MC OSCILLATOR ALIGNMENT.

a. With the calibrator removed from the Tuning Head, connect plug P907 to receptacle J907 on the calibrator chassis.

b. Connect pins A and E of receptacle J905 to the 6.3 VAC and ground terminals respectively on the power supply.

c. Turn on the power supply 6.3 VAC filament voltage stage and the frequency counter and allow a 5-minute warm-up period.

d. Connect a milliammeter between +250 VDC terminal on the power supply and pin E of receptacle J905.

e. Rotate the LEVEL control fully counterclockwise and turn the tuning slugs of inductor L910 and capacitor C901 all the way out.

f. Turn on the +250 VDC supply and set the RF CAL switch to the 1 MC position. Note that the milliammeter indicates 8 MA or above.

g. Screw in the slug of inductor L910 until a sharp current dip is observed on the milliammeter.

h. Rotate the LEVEL control fully clockwise and adjust inductor L910 for a 20 MA indication on the milliammeter.

i. Connect the frequency counter to receptacle J901 and adjust capacitor C901 so that the counter indicates 1 MC ±100 cps.

j. Readjust inductor L910 and capacitor C901 if necessary to maintain 20 MA and 1 MC ±100 cps.

k. Set the RF CAL switch to the OFF position and back to the 1 MC position several times and note that the current reading jumps to 20 MA each time the oscillator is started.

l. Rotate the LEVEL control from fully clockwise to fully counterclockwise and note that the oscillator frequency remains within the specification in step j.

5-119. 10 MC OSCILLATOR ALIGNMENT.

a. Rotate the LEVEL control fully counterclockwise and turn the tuning slugs of inductor L908 and capacitor C902 all the way out.

b. Set the RF CAL switch to the 10 MC position and note that the milliammeter indicates 8 MA or above.

c. Screw in the slug of inductor L908 until a sharp current dip is observed on the milliammeter.

d. Rotate the LEVEL control fully clockwise and adjust L908 for a 20 MA indication on the milliammeter.

e. Adjust capacitor C902 until the counter reads 10 MC ±1000 cps on the frequency counter.

f. Readjust inductor L908 and capacitor C902 if necessary to maintain 20 MA and 10 MC ±1000 cps.

g. Set the RF CAL switch to the OFF position and back to the 10 MC position several times and note that the current reading jumps to 20 MA each time the oscillator is started.

h. Rotate the LEVEL control from fully clockwise to fully counterclockwise and note that the oscillator frequency remains within the specification in step e.

5-120. 100 MC OSCILLATOR ALIGNMENT.

a. Rotate the LEVEL control fully counterclockwise and turn the tuning slugs of inductors L903, 904, and 906 all the way out.

b. Set the RF CAL switch to the 100 MC position and note that the milliammeter indicates 40 MA or above.

c. Screw in the slug of inductor L906 until a sharp current dip is observed on the milliammeter. (The current will dip to about 25-30 MA.)

d. Turn the RF CAL switch to the OFF position and connect the input receptacle of the attenuator to receptacle J903.

e. Connect the attenuator to the thermistor mount and the mount to the power meter.

f. Note the instructions for the thermistor mount and adjust the power meter for the proper resistance and coefficient.

g. Turn off the power meter bias switch and rotate the coarse end fine zero controls fully counterclockwise.

h. Set the power meter to the 10 MW range and turn on the power. Allow a 5-minute warm-up period.

i. Adjust the power meter bias and the coarse and fine zero controls to zero the meter.

j. Set the attenuator for 20 db attenuation and set the RANGE switch to the 100 MC position.

k. Adjust inductors L903, L904, and L906 for +20-25 DBM of output power.

l. Disconnect the attenuator and power meter and connect the frequency counter to receptacle J903. Note that the counter reads 100 MC ±10,000 cps.

TABLE 5-7. TUBE SOCKET VOLTAGE AND RESISTANCE CHART – CRYSTAL CALIBRATOR

Pin No.	V901 (6922) (Note 1)		V901 (6922) (Note 2)		V902 (6CB6) (Note 3)		V903 (12BY7A) (Note 3)	
	V	R	V	R	V	R	V	R
1	0	Inf.	40 to 250	Inf.	-.66	22 K	4.6	500
2	0	100 K	-7 to -13.5	100 K	1.4	75	0	30 K
3	0	51	.32 to 1.0	51	6.3 VAC	.2	0	0
4	0	0	0	0	0	0	0	0
5	6.3 VAC	0.5	6.3 VAC	0.5	70	Inf.	0	0
6	100-250	Inf.	0	Inf.	120	Inf.	6.3 VAC	.2
7	-38 to -82	95 K	0	95 K	0	0	200	Inf.
8	-32 to -95	50	0	50	---	---	160	Inf.
9	0	0	0	0	---	---	0	0

NOTES:

1. Voltages measured with R.F. CAL. switch in 1 MC position.
2. Voltages measured with R.F. CAL. switch in 10 MC position.
3. Voltages measured with R.F. CAL. switch in 100 MC position.
4. All voltages are +DC volts unless otherwise indicated.
5. Range of voltage indicates LEVEL control CCW to CW.
6. Resistance measurements made with P905 disconnected.
7. All resistance in ohms unless otherwise indicated.

SECTION 6

REPLACEMENT PARTS LIST

6-1. GENERAL.

6-2. This section contains a list of all electrical and electronic replaceable parts.

6-3. The parts list is arranged in alphabetical and numberical order by the circuit reference designation, and is cross-referenced to its description and part number.

6-4. Values and ratings of some components are nominal or factory selected and variations may exist in some models. In cases where variations are found, use the exact replacement for the component found in the equipment.

6-5. When ordering parts from the factory, always include the following information:

a. Instrument Model Number
b. Instrument Serial Number
c. Singer Part Number
d. Reference Designation
e. Part Description
f. Quantity Required

Ref. Desig.	Description	Singer Part No.
C101	CAPACITOR: fixed, electrolytic, 20 uf, 600 V	556066-012
C102	CAPACITOR: fixed, electrolytic, 20 uf, 600 V	556066-012
C103	CAPACITOR: fixed, metallized paper, .25 uf, 200 V	556120-145
C104	CAPACITOR: fixed, ceramic, .02 uf, 500 V	556060-023
C105	CAPACITOR: fixed, ceramic, .05 uf, 500 V	556060-081
C107	CAPACITOR: fixed, electrolytic, 20 uf, 600 V	556066-012
C109	CAPACITOR: fixed, oil filled, 4 uf, 2000 V	556116-003
C111	CAPACITOR: fixed, paper dielectric, 4 uf, 600 V	556106-002
C112	CAPACITOR: fixed, metallized paper, 2 uf, 200 V	556120-142
C113	CAPACITOR: fixed, metallized paper, 1 uf, 400 V	556120-151
C115	CAPACITOR: fixed, ceramic, .1 uf, 600 V	556060-058
C117	CAPACITOR: fixed 3 x 20 uf, 350 V	556065-004
C119	CAPACITOR: fixed, ceramic, .01 uf, 600 V	556060-013
C121	CAPACITOR: fixed, Mylar, dip-coated, tubular, .1 uf, 400 V	556120-126
C123	CAPACITOR: fixed, metallized paper, .1 uf, 200 V	556120-146
C124	CAPACITOR: fixed, silver mica, 43 uuf	556079-023
C125	CAPACITOR: fixed, silver mica, 510 uuf	556125-010
C126	CAPACITOR: fixed, Mylar tubular, .1 uf, 100 V	556120-130
C129	CAPACITOR: fixed, ceramic, .005 uf, 3000 V	556060-041
C131	CAPACITOR: fixed, ceramic, .005 uf, 3000 V	556060-041
C133	CAPACITOR: fixed, electrolytic, 2000 uf, 50 V	556075-001
C201	CAPACITOR: fixed, ceramic, 68 uuf	150-4001-R68M
C202	CAPACITOR: fixed, feed-thru, 1000 uuf, ±5%, 500 V	556060-071
C203	CAPACITOR: variable, .8-4.5 uuf	556122-053
C204	CAPACITOR: fixed, feed-thru, 1000 uuf, ±5%, 500 V	556060-071
C205	CAPACITOR: variable, .8-4.5 uuf	556122-053
C206	CAPACITOR: fixed, ceramic, .02 uf, 500 V	556060-023
C207	CAPACITOR: variable, .8-4.5 uuf	556122-053
C208	CAPACITOR: fixed, ceramic, .68 uuf	150-4001-R68M
C209	CAPACITOR: variable, .8-4.5 uuf	556122-053
C210	CAPACITOR: fixed, ceramic, .68 uuf	150-4001-R68M
C211	CAPACITOR: fixed, silver mica, 15 uuf	556099-001
C212	CAPACITOR: fixed, ceramic 6.68 uuf	150-4001-R68M
C213	CAPACITOR: fixed, ceramic, 1 uuf, ±5%	150-4001-1ROJ
C214	CAPACITOR: fixed, ceramic, .68 uuf	150-4001-R68M
C217	CAPACITOR: variable, .8-4.5 uuf	556122-064
C219	CAPACITOR: fixed, Durmica, 22 uuf	150-2002-202 CJO
C221	CAPACITOR: fixed, Durmica, 24 uuf	150-2002-240 CJO
C223	CAPACITOR: fixed, Durmica, 15 uuf	556125-007
C225	CAPACITOR: fixed, Durmica, 150 uuf	150-2002-151 EJO
C227	CAPACITOR: variable, 1-12 uuf	556122-056
C229	CAPACITOR: fixed, feed-thru, 1000 uuf, ±5%, 500 V	556060-071
C231	CAPACITOR: fixed, feed-thru, 1000 uuf, ±5%, 500 V	556060-071
C233	CAPACITOR: fixed, feed-thru, 1000 uuf, ±5%, 500 V	556060-071
C235	CAPACITOR: fixed, feed-thru, 1000 uuf, ±5%, 500 V	556060-071
C237	CAPACITOR: variable, 1-12 uuf	556122-056
C239	CAPACITOR: fixed, Durmica, 10 uuf	150-2002-100 CJO
C241	CAPACITOR: variable, 1-12 uuf	556122-056
C242	CAPACITOR: fixed, Durmica, 10 uuf	150-2002-100 CJO

Ref. Desig.	Description	Singer Part No.
C243	CAPACITOR: fixed, Durmica, 150 uuf	150-2002-151 EJO
C245	CAPACITOR: fixed, feed-thru, 1000 uuf, ±5%, 500 V	556060-071
C247	CAPACITOR: fixed, feed-thru, 1000 uuf, ±5%, 500 V	556060-071
C249	CAPACITOR: fixed, feed-thru, 1000 uuf, ±5%, 500 V	556060-071
C251	CAPACITOR: fixed, feed-thru, 1000 uuf, ±5%, 500 V	556060-071
C253	CAPACITOR: variable, 1-12 uuf	556122-056
C255	CAPACITOR: fixed, Durmica, 10 uuf	150-2002-151 EJO
C257	CAPACITOR: fixed, Durmica, 150 uuf	150-2002-151 EJO
C259	CAPACITOR: variable, 1-12 uuf	556122-056
C259(A)	CAPACITOR: fixed, electrolytic, 4 uf, 350 V	556072-001
C261	CAPACITOR: fixed, electrolytic, 4 uf, 350 V	556072-001
C262	CAPACITOR: fixed, feed-thru, 1000 uuf, ±5%, 500 V	556060-071
C263	CAPACITOR: fixed, electrolytic, 2000 uf, 15 V	556062-003
C264	CAPACITOR: fixed, feed-thru, 1000 uuf, ±5%, 500 V	556060-071
C265	CAPACITOR: fixed, electrolytic, 2000 uf, 15 V	556062-003
C267	CAPACITOR: fixed, ceramic, .1 uf, 600 V	556060-058
C269	CAPACITOR: fixed, ceramic, 1 uuf	556060-009
C271	CAPACITOR: fixed, ceramic, 15 uuf	556060-003
C273	CAPACITOR: fixed, ceramic, 15 uuf	556060-003
C275	CAPACITOR: fixed, ceramic, 2.2 uuf	150-4001-2R2K
C277	CAPACITOR: fixed, ceramic, 15 uuf	556060-003
C279	CAPACITOR: fixed, ceramic, 2.2 uuf	150-4001-2R2K
C281	CAPACITOR: fixed, ceramic, 1 uuf	556060-009
C283	CAPACITOR: fixed, ceramic, 1 uuf	556060-009
C285	CAPACITOR: fixed, ceramic, 15 uuf	556060-003
C287	CAPACITOR: fixed, ceramic, 1 uuf	556060-009
C289	CAPACITOR: fixed, ceramic, 15 uuf	556060-003
C291	CAPACITOR: fixed, ceramic, 15 uuf	556060-003
C301	CAPACITOR: fixed, mica, 150 uuf	556079-005
C303	CAPACITOR: variable, 1-18 uuf	556122-015
C305	CAPACITOR: fixed, feed-thru, 1000 uuf, ±5%, 500 V	556060-071
C307	CAPACITOR: fixed, feed-thru, 1000 uuf, ±5%, 500 V	556060-071
C309	CAPACITOR: fixed, feed-thru, 1000 uuf, ±5%, 500 V	556060-071
C311	CAPACITOR: fixed, mica, 5 uuf	556078-001
C313	CAPACITOR: variable, 1-18 uuf	556122-015
C314	CAPACITOR: fixed, silver mica, 10 uuf	556076-022
C315	CAPACITOR: variable, 1-18 uuf	556122-015
C317	CAPACITOR: fixed, mica, 150 uuf	556079-005
C319	CAPACITOR: fixed, feed-thru, 1000 uuf, ±5%, 500 V	556060-071
C321	CAPACITOR: fixed, feed-thru, 1000 uuf, ±5%, 500 V	556060-071
C323	CAPACITOR: fixed, feed-thru, 1000 uuf, ±5%, 500 V	556060-071
C325	CAPACITOR: fixed, mica, 5 uuf	556078-001
C327	CAPACITOR: variable, 1-18 uuf	556122-015
C329	CAPACITOR: fixed, mica, 150 uuf	556079-005
C331	CAPACITOR: variable, 1-18 uuf	556122-015
C333	CAPACITOR: fixed, feed-thru, 1000 uuf, ±5%, 500 V	556060-071
C339	CAPACITOR: fixed, ceramic, tubular, 30 uuf	556060-018
C341	CAPACITOR: fixed, button, 1000 uuf	556099-002
C343	CAPACITOR: fixed, ceramic, .01 uf	556060-073

Ref. Desig.	Description	Singer Part No.
C345	CAPACITOR: fixed, ceramic, .01 uf	556060-073
C347	CAPACITOR: fixed, ceramic, .05 uf	556060-081
C349	CAPACITOR: fixed, ceramic, .02 uf	556060-023
C351	CCAPACITOR: fixed, mica, 47 uuf	556079-025
C353	CAPACITOR: fixed, ceramic, .01 uf	556060-073
C359	CAPACITOR: fixed, ceramic, .02 uf	556060-023
C361	CAPACITOR: trimmer, 8-50 uuf	556120-011
C364	CAPACITOR: fixed, feed-thru, 1000 uuf, ±5%, 500 V	556060-071
C365	CAPACITOR: fixed, feed-thru, 1000 uuf, ±5%, 500 V	556060-071
C366	CAPACITOR: fixed, ceramic, .001 uf	556060-046
C367	CAPACITOR: fixed, ceramic, .001 uf	556060-046
C370	CAPACITOR: fixed, feed-thru, 1000 uuf, ±5%, 500 V	556060-071
C371	CAPACITOR: fixed, feed-thru, 1000 uuf, ±±5%, 500 V	556060-071
C372	CAPACITOR: fixed, feed-thru, 1000 uuf, ±5%, 500 V	556060-071
C375	CAPACITOR: fixed, ceramic, 20 uuf	556060-045
C377	CAPACITOR: fixed, ceramic, .68 uuf	150-4001-R68M
C379	CAPACITOR: fixed, ceramic, 20 uuf	556060-045
C401	CAPACITOR: fixed, ceramic, 68 uuf, 500 V	150-2002-680 EJO
C403	CAPACITOR: variable, glass trimmer, 1-9 uuf, 750 V	150-0002-001
C405	CAPACITOR: variable, glass trimmer, 1-9 uuf, 750 V	150-0002-001
C407	CAPACITOR: variable, glass trimmer, 3.4-22.5 uuf, 700 V	150-0001-001
C409	CAPACITOR: fixed, mica, 47 uuf, 500 V	150-2002-470 EJO
C411	CAPACITOR: fixed, ceramic, .001 uf, 500 V	150-1002-102 PHC
C413	CAPACITOR: stand-off, 1000 uuf	556060-169

Ref. Desig.	Description	Singer Part No.
C601	CAPACITOR: fixed, silver mica, 510 uuf	556079-028
C602	CAPACITOR: fixed, button, 1000 uuf	556099-002
C604	CAPACITOR: fixed, button, 1000 uuf	556099-002
C605	CAPACITOR: fixed, silver mica, 510 uuf	556079-028
C607	CAPACITOR: fixed, ceramic, .02 uf, 500 V	556060-023
C608	CAPACITOR: fixed, button, 1000 uuf	556099-002
C610	CAPACITOR: fixed, button, 1000 uuf	556099-002
C611	CAPACITOR: fixed, button, 1000 uuf	556099-002
C612	CAPACITOR: fixed, silver mica, 39 uuf	556079-021
C613	CAPACITOR: fixed, silver mica, 30 uuf	556079-016
C614	CAPACITOR: fixed, ceramic, .02 uf, 500 V	556060-023
C615	CAPACITOR: fixed, ceramic, .02 uf, 500 V	556060-023
C616	CAPACITOR: fixed, ceramic, 5 uuf	556060-006
C617	CAPACITOR: fixed, button, 1000 uuf	556099-002
C618	CAPACITOR: fixed, ceramic, .02 uf, 500 V	556060-023
C619	CAPACITOR: fixed, ceramic, .001 uf, 1000 V	556060-046
C620	CAPACITOR: fixed, ceramic, .02 uf, 500 V	556060-023
C623	CAPACITOR: fixed, ceramic, .02 uf, 500 V	556060-023
C624	CAPACITOR: fixed, ceramic, .02 uf, 500 V	556060-023
C625	CAPACITOR: fixed, ceramic, .02 uf, 500 V	556060-023
C626	CAPACITOR: fixed, ceramic, .001 uf, 1000 V	556060-046
C627	CAPACITOR: variable, 3-12 uuf	556122-034
C628	CAPACITOR: fixed, ceramic, .02 uf, 500 V	556060-023
C629	CAPACITOR: fixed, 3.3 uuf, ±5%, 500 V	150-4001-3R3J
C630	CAPACITOR: fixed, ceramic, .02 uf, 500 V	556060-023

Ref. Desig.	Description	Singer Part No.
C631	CAPACITOR: fixed, ceramic, .02 uf, 500 V	556060-023
C632	CAPACITOR: fixed, ceramic, .02 uf, 500 V	556060-023
C633	CAPACITOR: fixed, ceramic, .001 uf, 1000 V	556060-046
C634	CAPACITOR: fixed, ceramic, .02 uf, 500 V	556060-023
C635	CAPACITOR: fixed, ceramic, .001 uf, 1000 V	556060-046
C636	CAPACITOR: tubular, ceramic, 7.5 ±.25 uuf	556146-134
C637	CAPACITOR: fixed, ceramic, 3.3 uuf, ±5%, 500 V	150-4001-3R3J
C638	CAPACITOR: fixed, ceramic, .02 uf, 500 V	556060-023
C639	CAPACITOR: fixed, ceramic, .02 uf, 500 V	556060-023
C641	CAPACITOR: fixed, ceramic, .02 uf, 500 V	556060-023
C642	CAPACITOR: variable, 3-12 uuf	556122-034
C643	CAPACITOR: fixed, ceramic, .02 uf, 500 V	556060-023
C644	CAPACITOR: tubular, ceramic, 7.5 ±.25 uuf	556146-134
C645	CAPACITOR: fixed, ceramic, .02 uf, 500 V	556060-023
C646	CAPACITOR: fixed, ceramic, .02 uf, 500 V	556060-023
C647	CAPACITOR: fixed, ceramic, .02 uf, 500 V	556060-023
C648	CAPACITOR: tubular, ceramic, 7.5 ±.25 uuf	556146-134
C649	CAPACITOR: fixed, ceramic, .02 uf, 500 V	556060-023
C650	CAPACITOR: fixed, ceramic, .02 uf, 500 V	556060-023
C651	CAPACITOR: fixed, ceramic, .02 uf, 500 V	556060-023
C653	CAPACITOR: fixed, ceramic, .02 uf, 500 V	556060-023
C654	CAPACITOR: fixed, ceramic, .02 uf, 500 V	556060-023
C655	CAPACITOR: fixed, ceramic, .02 uf, 500 V	556060-023
C657	CAPACITOR: fixed, ceramic, .02 uf, 500 V	556060-023
C658	CAPACITOR: fixed, ceramic, .02 uf, 500 V	556060-023
C659	CAPACITOR: fixed, ceramic, .02 uf, 500 V	556060-023
C661	CAPACITOR: fixed, ceramic, .02 uf, 500 V	556060-023
C662	CAPACITOR: fixed, ceramic, .02 uf, 500 V	556060-023
C663	CAPACITOR: fixed, ceramic, .02 uf, 500 V	556060-023
C665	CAPACITOR: fixed, ceramic, .02 uf, 500 V	556060-023
C666	CAPACITOR: fixed, ceramic, .02 uf, 500 V	556060-023
C667	CAPACITOR: fixed, silver mica, 100 uuf, ±5%	556076-013
C669	CAPACITOR: fixed, silver mica, 36 uuf	556079-039
C670	CAPACITOR: fixed, ceramic, .05 uf, 500 V	556060-081
C671	CAPACITOR: fixed, silver mica, 300 uuf	150-4001-R68M
C672	CAPACITOR: fixed, ceramic, .05 uf, 500 V	556060-081
C674	CAPACITOR: fixed, ceramic, .05 uf, 500 V	556060-081
C675	CAPACITOR: fixed, silver mica, 270 uuf	556079-015
C676	CAPACITOR: fixed, ceramic, .02 uf, 500 V	556060-023
C677	CAPACITOR: fixed, ceramic, .05 uf, 500 V	556060-081
C678	CAPACITOR: fixed, silver mica, 510 uuf	556079-028
C681	CAPACITOR: fixed, feed-thru, 1000 uuf, ±5%, 500 V	556060-071
C683	CAPACITOR: fixed, ceramic, .02 uf, 500 V	556060-023
C701	CAPACITOR: fixed, ceramic, .005 uf	556060-041
C703	CAPACITOR: fixed, ceramic, .005 uf	556060-041
C705	CAPACITOR: fixed, ceramic, .05 uf	556060-037
C801	CAPACITOR: fixed, ceramic, .01 uf, 500 V	556060-073
C803	CAPACITOR: fixed, ceramic, .01 uf, 500 V	556060-073
C805	CAPACITOR: fixed, Mylar, flat tubular, .0047 uf, 400 V	556120-104

Ref. Desig.	Description	Singer Part No.
C807	CAPACITOR: fixed, ceramic, .01 uf, 500 V	556060-073
C809	CAPACITOR: fixed, .022 uf, 150 V	556120-106
C811	CAPACITOR: fixed, 91 uuf	556079-035
C813	CAPACITOR: fixed, 4.0 uf	556108-001
C815	CAPACITOR: fixed, ceramic, .001 uf	556060-046
C817	CAPACITOR: fixed, ceramic, .001 uf	556060-046
C901	CAPACITOR: fixed, ceramic, .01 uf, 500 V	556060-073
C902	CAPACITOR: fixed, mica, 24 uuf	221-63-087BW
C903	CAPACITOR: fixed, 2.2 uuf	150-4001-2R2K
C904	CAPACITOR: variable, ceramic, 5-50 uuf	556122-020
C905	CAPACITOR: fixed, ceramic, .01 uf, 500 V	556060-073
C907	CAPACITOR: fixed, mica, 240 uuf	556079-013
C909	CAPACITOR: fixed, mica, 82 uuf	556079-034
C910	CAPACITOR: fixed, mica, 18 uuf	556079-036
C911	CAPACITOR: fixed, 4.7 uf	556060-021
C912	CAPACITOR: variable, ceramic, 0.6-6 uuf	556122-012
C913	CAPACITOR: fixed, ceramic, 1000 uuf	556060-046
C914	CAPACITOR: variable, button type trimmer, 1.5-7 uuf	556122-076
C915	CAPACITOR: fixed, 2.2 uuf	150-4001-2R2K
C917	CAPACITOR: fixed, ceramic, 510 uuf	556079-028
C919	CAPACITOR: fixed, 2.2 uf	150-4001-2R2K
C920	CAPACITOR: fixed, ceramic, 510 uuf	556079-028
C921	CAPACITOR: fixed, ceramic, 510 uuf	556079-028
C923	CAPACITOR: fixed, mica, 200 uuf	556079-008
C928	CAPACITOR: fixed, ceramic, 510 uuf	556079-028
C929	CAPACITOR: fixed, ceramic, 510 uuf	556079-028
C931	CAPACITOR: fixed, ceramic, 510 uuf	556079-028
C933	CAPACITOR: fixed, 2.2 uuf	150-4001-2R2K
C935	CAPACITOR: fixed, ceramic, 510 uuf	556079-028
CP210	SAMPLER: signal	556001-156
CR101	DIODE: silicon rectifier	556118-029
CR103	DIODE: silicon rectifier	556118-029
CR105	DIODE: silicon rectifier	556118-029
CR107	DIODE: silicon rectifier	556118-029
CR109	DIODE: silicon rectifier	556118-027
CR111	DIODE: silicon rectifier	556118-027
CR113	DIODE: silicon rectifier	556118-027
CR115	DIODE: silicon rectifier	556118-027
CR117	DIODE: silicon rectifier	556118-030
CR119	DIODE: silicon rectifier	556118-030
CR121	DIODE: silicon rectifier	556118-030
CR123	DIODE: silicon rectifier	556118-030
CR125	DIODE: silicon rectifier	556118-028
CR127	DIODE: silicon rectifier	556118-028
CR129	DIODE: silicon rectifier	556118-028
CR131	DIODE: silicon rectifier	556118-028
CR133	DIODE: Zener, silicon, 1N1605	556118-031
CR133(A)	RECTIFIER: minisel, selenium	556118-023
CR135	RECTIFIER: minisel, selenium	556118-023
CR201	DIODE: 1N1089	556118-033
CR203	DIODE: 1N1089	556118-033
CR205	DIODE: 1N1089	556118-033
CR207	DIODE: 1N1089	556118-033
CR209	DIODE: 1N1089	556118-033
CR211	DIODE: 1N1089	556118-033
CR213	DIODE: 1N1089	556118-033
CR215	DIODE: 1N1089	556118-033
CR217	RECTIFIER: selenium, half-wave	556118-014
CR219	RECTIFIER: selenium, half-wave	556118-014
CR221	RECTIFIER: Zener, silicon	556118-017

Ref. Desig.	Description	Singer Part No.
CR223	DIODE: 1N358A	556118-035
CR225	DIODE: 1N26	556118-040
CR334	DIODE: 1N128	556118-045
CR401	DIODE: 1N34A	556118-041
CR403	DIODE: 1N34A	556118-041
CR405	DIODE: 1N34A	556118-041
CR407	DIODE: 1N34A	556118-041
CR601	CRYSTAL: filter, 6.5 mc	556025-015
CR602	CRYSTAL: filter, 6.5 mc	556025-016
CR901	DIODE: 1N914	556118-145
CR903	DIODE: 1N914	556118-145
DS101	LAMP: miniature, type 349	160-6001-002
DS103	LAMP: miniature, type 349	160-6001-002
DS105	LAMP: miniature, type 349	160-6001-002
DS107	LAMP: miniature, type 349	160-6001-002
DS201	LAMP: miniature, type 349	160-6001-002
DS202	LAMP: miniature, type 349	160-6001-002
DS203	LAMP: miniature, type 349	160-6001-002
DS204	LAMP: miniature, type 349	160-6001-002
DS205	LAMP: miniature, type 349	160-6001-002
DS206	LAMP: miniature, type 349	160-6001-002
DS801	LAMP: miniature, type 51	556002-061
E601	LAMP: glow, neon, type NE-2	556002-030
E801	LAMP: glow, neon, type NE-16 (mod.)	556002-035
F101	FUSE: instant, 4 ampere, 250 V	556006-121
F102	FUSE: instant, 4 ampere, 250 V	556006-121
SPARE	FUSE: instant, 5 ampere, 250 V	556006-121
SPARE	FUSE: instant, 5 ampere, 250 V	556006-121
FL401	FILTER: low pass	156-9001-001
FL402	FILTER: low pass	156-9001-001
FL403	FILTER: low pass	156-9001-001
J301	CONNECTOR: receptacle	556010-118
J305	CONNECTOR: receptacle	556010-118
J307	CONNECTOR: receptacle	556010-118
J313	CONNECTOR: receptacle	556010-118
J315	CONNECTOR: receptacle	556010-118

Ref. Desig.	Description	Singer Part No.
J901	JACK: BNC Type UG-1094/U	556010-038
J903	JACK: BNC Type UG-1094/U	556010-038
J905	JACK: male, 5-pin	556010-062
J907	JACK: female, 7-pin	556010-040
L103	CHOKE: RF, fixed, 50 mh	556012-019
L104	CHOKE: RF, fixed, .8 mh	556012-040
L201	CHOKE	556026-307
L202	CHOKE: RF, 1.5 uh	556012-092
L203	CHOKE	556026-307
L205	COIL: RF (Factory Adjusted)	556026-339
L207	COIL: RF (Factory Adjusted)	556026-340
L209	COIL: RF (Factory Adjusted)	556026-340
L211	COIL: (Factory Adjusted)	132-0022-001
L213	CHOKE: 2.7 uh	556012-091
L214	CHOKE: 5.6 uh	556012-175
L215	CHOKE: 2.7 uh	556012-091
L216	CHOKE: 5.6 uh	556012-175
L217	CHOKE: RF (Factory Adjusted)	556026-027
L219	CHOKE: RF (Factory Adjusted)	556026-022
L221	CHOKE: RF (Factory Adjusted)	556026-021
L225	CHOKE: 2.7 uh	556012-091
L227	CHOKE: RF (Factory Adjusted)	556026-024
L228	CHOKE: 5.6 uh	556012-175
L229	CHOKE: RF (Factory Adjusted)	556026-027
L230	CHOKE: 5.6 uh	556012-175
L231	CHOKE: RF (Factory Adjusted)	556026-024
L232	CHOKE: 2.7 uh	556012-091
L233	CHOKE: RF (Factory Adjusted)	556026-025
L234	CHOKE: 2.7 uh	556012-091
L235	COIL: (Factory Adjusted)	132-0018-001
L236	CHOKE: 5.6 mh	556012-175
L237	COIL: 160 mc band pass filter	556026-343
L239	COIL: 160 mc band pass filter	556026-343
L241	COIL: 160 mc band pass filter	556026-343
L243	COIL: 160 mc band pass filter	556026-343
L245	COIL: 160 mc band pass filter	556023-343
L247	COIL: 160 mc band pass filter	556023-343

Ref. Desig.	Description	Singer Part No.
L249	COIL: 160 mc band pass filter	556023-343
L251	COIL: 160 mc band pass filter	556023-343
L301	COIL: (Factory Adjusted)	132-0021-001
L302	CHOKE: 5.6 uh	556012-175
L303	CHOKE: (Factory Adjusted)	556012-091
L304	CHOKE: 5.6 uh	556012-175
L305	COIL: (Factory Adjusted)	556026-027
L307	COIL: RF	556026-022
L315	COIL: (Factory Adjusted)	556026-021
L317	COIL: (Factory Adjusted)	556026-024
L318	CHOKE: 5.6 uh	556012-175
L320	CHOKE: 5.6 uh	556012-175
L323	COIL: (Factory Adjusted)	556026-023
L325	COIL: (Factory Adjusted)	556026-024
L329	COIL: (Factory Adjusted)	556026-025
L331	COIL: (Factory Adjusted)	556026-028
L334	COIL: 160 mc	132-0052
L335	CHOKE: RF, 1.5 uh	556012-092
L337	COIL: 160 mc wide band amplifier	556026-289
L338	COIL: 75 mc	556026-410
L340	COIL: 75 mc	556026-410
L343	CHOKE: RF, 1.5 uh	556012-092
L345	CHOKE: RF, 1.5 uh	556012-092
L347	INCREDUCTOR: sweep osc.	556012-104
L350	CHOKE: RF, 1.5 uh	556012-092
L351	CHOKE: RF, .75 uh	556026-472
L352	CHOKE: RF, 1.5 uh	556012-092
L401	CHOKE: 1 turn No. 22 wire on 15 ohm, 1/2 W resistor (R405)	132-0075
L403	CHOKE: RF, .75 uh	556026-472
L405	CHOKE: RF, 1.5 uh	556012-092
L407	COIL: variable, marker mod.	132-0109
L601	COIL: 75 mc	556160-113
L603	COIL: 75 mc	556160-114
L605	COIL: 75 mc	556160-114
L607	CHOKE: RF, fixed, 2.5 mh	556012-016
L608	CHOKE: RF, .56 uh	556012-003
L609	COIL: 68.5 mc osc.	556160-112
L611	COIL: 6.5 mc	556026-298
L613	CHOKE: RF, 500 mh	556012-022
L615	CHOKE: RF, fixed, 2.5 mh	556012-016
L617	CHOKE: RF, fixed, 2.5 mh	556012-016
L619	CHOKE: RF, fixed, 2.5 mh	556012-016
L620	CHOKE: RF, .56 uh	556012-003
L621	CHOKE: RF, fixed, 2.5 mh	556012-016
L625	CHOKE: RF, fixed, .8 uh	556012-040
L627	CHOKE: RF, fixed, .8 uh	556012-040
L629	CHOKE: RF, fixed, .8 uh	556012-040
L631	CHOKE: RF, fixed, .8 uh	556012-040
L633	CHOKE: RF, fixed, .8 uh	556012-040
L635	CHOKE: RF, fixed, .8 uh	556012-040
L903	COIL: 100 mc osc., plate tuning	132-0019-001
L904	COIL: 100 mc amp.	132-0019-001
L906	COIL: 100 mc osc., grid tuning	556162-530
L908	COIL: green core	255-01-057C
L910	COIL: green core	255-01-053C
L911	COIL: 160 mc trap, .24 uh	556168-526
R101	RESISTOR: fixed, composition, 120 ohms, ±5%, 1/2 W	151-1003-121J
R102	RESISTOR: fixed, composition; 1 megohm, ±5%, 2 W	151-1005-105J
R103	RESISTOR: fixed, composition, 120 ohms, ±5%, 1/2 W	151-1003-121J
R105	RESISTOR: fixed, composition, 120 ohms, ±5%, 1/2 W	151-1003-121J
R107	RESISTOR: fixed, composition, 47 ohms, ±5%, 1 W	151-1004-470J
R109	RESISTOR: fixed, composition, 1000 ohms, ±5%, 1/2 W	151-1003-101J
R111	RESISTOR: fixed, composition, 47 ohms, ±5%, 1 W	151-1004-470J
R113	RESISTOR: fixed, composition, 1000 ohms, ±5%, 1/2 W	151-1003-101J
R115	RESISTOR: fixed, composition, 47 ohms, ±5%, 1 W	151-1004-470J
R117	RESISTOR: fixed, composition, 1000 ohms, ±5%, 1/2 W	151-1003-101J

Ref. Desig.	Description	Singer Part No.
R119	RESISTOR: fixed, composition, 2.2 megohoms ± 5%, ½ W	151-1003-225J
R121	RESISTOR: fixed, composition, 240,000 ohms ±5%, 1/2 W	151-1003-244J
R123	RESISTOR: fixed, composition, 20,000 ohms ± 5%, 2 W	151-1005-203J
R125	RESISTOR: fixed, composition, 68,000 ohms ± 5%, ½ W	151-1003-683J
R127	RESISTOR: fixed, composition, 100,000 ohms ± 5%, ½ W	151-1003-104J
R129	RESISTOR: fixed, composition, 390,000 ohms ± 5%, ½ W	151-1003-394J
R131	RESISTOR: fixed, composition, 82,000 ohms ± 5%, ½ W	151-1003-823J
R133	RESISTOR: fixed, composition, 390,000 ohms ± 5%, ½ W	151-1003-394J
R135	RESISTOR: fixed, composition, 680,000 ohms ±5%, ½ W	151-1003-684J
R137	RESISTOR: variable, 50,000 ohms, 2 W	556052-014
R139	RESISTOR: fixed, composition, 150,000 ohms, ±5%, 1/2 W	151-1003-154J
R140	RESISTOR: fixed, composition, 470,000 ohms, ±5%, 2 W	151-1005-474J
R141	RESISTOR: fixed, composition, 470,000 ohms, ±5%, 2 W	151-1005-474J
R142	RESISTOR: fixed, composition, 100 ohms, ±5%, 1 W	151-1004-101J
R143	RESISTOR: fixed, compostion, 150,000 ohms, ±5%, 1/2 W	151-1003-154J
R145	RESISTOR: fixed, composition, 150,000 ohms, ±5%, 1/2 W	151-1003-154J
R147	RESISTOR: fixed, composition, 150,000 ohms, ±5%, 1/2 W	151-1003-154J
R149	RESISTOR: fixed, composition, 150,000 ohms, ±5%, 1/2 W	151-1003-154J
R151	RESISTOR: fixed, composition, 2.2 megohms, ±5%, 1/2 W	151-1003-225J
R152	RESISTOR: fixed, composition, 2000 ohms, ±5%, 1 W	151-1004-202J
R155	RESISTOR: fixed, wirewound, 20,000 ohms, 10 W	556045-014
R157	RESISTOR: fixed, wirewound, 15,000 ohms, ±5%, 10 W	556045-020
R158	RESISTOR: fixed, composition, 22 ohms, ±5%, 1/2 W	151-1003-220J
R159	RESISTOR: fixed, composition, 360,000 ohms, ±5%, 1/2 W	151-1003-364J
R160	RESISTOR: fixed, composition, 200 ohms, ±5%, 1/2 W	151-1003-201J
R161	RESISTOR: variable, 25,000 ohms, ±10%, 2 W	151-0007-023
R163	RESISTOR: fixed, composition, 150,000 ohms, ±5%, 1/2 W	151-1003-154J
R164	RESISTOR: fixed, composition, 1 megohm, ±5%, 2 W	151-1005-105J
R165	RESISTOR: fixed, composition, 1500 ohms, ±5%, 2 W	151-1005-152J
R167	RESISTOR: fixed, composition, 1500 ohms, ±5%, 2 W	151-1005-152J
R169	RESISTOR: fixed, composition, 1500 ohms, ±5%, 2 W	151-1005-152J
R171	RESISTOR: fixed, composition, 10,000 ohms, ±5%, 2 W	151-1005-103J
R172	RESISTOR: fixed, composition, 1000 ohms, ±5%, 1/2 W	151-1003-101J
R173	RESISTOR: fixed, composition, 100,000 ohms, ±5%, 1/2 W	151-1003-104J
R180	RESISTOR: variable, wirewound, 6 ohms, ±10%, 2 W	556056-001
R181	RESISTOR: fixed, wirewound, 100 ohms, 22 W	556040-001
R183	RESISTOR: fixed, wirewound, 100 ohms, 22 W	556040-001
R185	RESISTOR: fixed, wirewound, 100 ohms, 22 W	556040-001
R201	RESISTOR: fixed, composition, 470 ohms, ±5%, 1/2 W	151-1003-471J
R203	RESISTOR: fixed, wirewound, 10,000 ohms, 5 W	556043-006
R205	RESISTOR: fixed, composition, 240 ohms, ±5%, 1/4 W	151-1002-241J
R207	RESISTOR: fixed, composition, 7500 ohms, ±5%, 1/2 W	151-1003-752J
R209	RESISTOR: fixed, composition, 51 ohms, ±5%, 1/2 W	151-1003-510J
R210	RESISTOR: fixed, composition, 50 ohms, ±10%, 1/4 W	151-1002-500K
R211	RESISTOR: fixed, composition, 62 ohms, ±5%, 1/2 W	151-1003-620J
R213	RESISTOR: fixed, composition, 62 ohms, ±5%, 1/2 W	151-1003-620J
R215	RESISTOR: fixed, composition, 68 ohms ±5%, 1/2 W	151-1003-680J
R217	RESISTOR: fixed, composition, 270 ohms, ±5%, 1/2 W	151-1003-271J
R219	RESISTOR: fixed, composition, 270 ohms, ±5%, 1/2 W	151-1003-271J
R221	RESISTOR: fixed, wirewound, 2000 ohms, ±5%, 20 W	556047-016

Ref. Desig.	Description	Singer Part No.
R223	RESISTOR: fixed, composition, 13,000 ohms, ±5%, 2 W	151-1005-133J
R225	RESISTOR: fixed, composition, 13,000 ohms, ±5%, 2 W	151-1005-133J
R227	RESISTOR: fixed, composition, 300 ohms, ±5%, 1/2 W	151-1003-301J
R231	RESISTOR: fixed, composition, 390 ohms, ±5%, 1/2 W	151-1003-391J
R233	RESISTOR: variable, 25,000 ohms, 2 W, w/hardware	151-0007-007
R235	RESISTOR: variable, 25,000 ohms, 2 W, w/hardware	151-0007-007
R237	RESISTOR: variable, 25,000 ohms, 2 W, w/hardware	151-0007-007
R239	RESISTOR: fixed, wirewound, 10,000 ohms, 10 W	556045-003
R241	RESISTOR: fixed, wirewound, 7500 ohms, 10 W	556045-048
R243	RESISTOR: fixed, composition, 300 ohms, ±5%, 1/2 W	151-1003-301J
R245	RESISTOR: variable, 1000 ohms, 2 W, w/hardware	151-0007-038
R247	RESISTOR: fixed, composition, 6.8 ohms, ±5%, 1 W	151-1004-6R8J
R248	RESISTOR: fixed, composition, 680,000 ohms, ±5%, 1/2 W	151-1003-684J
R249	RESISTOR: fixed, composition, 510,000 ohms, ±5%, 1/2 W	151-1003-514J
R251	RESISTOR: fixed, composition, 5600 ohms, ±5%, 2 W	151-1005-562J
R253	RESISTOR: fixed, composition, 390,000 ohms, ±5%, 2 W	151-1005-394J
R255	RESISTOR: variable, 10,000 ohms, 2 W	151-0007-006
R257	RESISTOR: variable, wirewound, 100,000 ohms, 8 W	556052-061
R259	RESISTOR: variable, 50,000 ohms, 2 W	151-0007-014
R265	RESISTOR: fixed, composition, 50 ohms, ±10%, 1/4 W	556050-001
R267	RESISTOR: fixed, composition, 50 ohms	556050-003
R268	RESISTOR: fixed, composition, 50 ohms, ±10%, 1/4 W	556050-001
R269	RESISTOR: fixed, composition, 50 ohms, ±10%, 1/4 W	556050-001
R301	RESISTOR: fixed, composition, 62 ohms, ±5%, 1/2 W	151-1003-620J
R302	RESISTOR: fixed, composition, 91 ohms, ±5%, 1/2 W	151-1003-910J
R303	RESISTOR: fixed, composition, 62 ohms, ±5%, 1/2 W	151-1003-620J
R304	RESISTOR: fixed, composition, 91 ohms, ±5%, 1/2 W	151-1003-910J
R306	RESISTOR: fixed, composition, 33 ohms, ±5%, 1/2 W	151-1003-330J
R308	RESISTOR: fixed, composition, 560 ohms, ±5%, 1/2 W	151-1003-561J
R309	RESISTOR: fixed, composition, 130 ohms, ±5%, 1/2 W	151-1003-131J
R313	RESISTOR: fixed, composition, 470,000 ohms, ±5%, 1/2 W	151-1003-474J
R314	RESISTOR: fixed, composition, 100,000 ohms, ±5%, 1/2 W	151-1003-104J
R315	RESISTOR: fixed, composition, 1200 ohms, ±5%, 1/2 W	151-1003-122J
R316	RESISTOR: fixed, composition, 10 ohms, ±5%, 1/2 W	151-1003-100J
R317	RESISTOR: fixed, composition, 75,000 ohms, ±5%, 2 W	151-1005-753J
R319	RESISTOR: fixed, composition, 200,000 ohms, ±5%, 1/2 W	151-1003-204J
R321	RESISTOR: fixed, composition, 10,000 ohms, ±5%, 1/2 W	151-1003-103J
R323	RESISTOR: fixed, composition, 100 ohms, ±5%, 1/2 W	151-1003-102J
R325	RESISTOR: fixed, composition, 150,000 ohms, ±5%, 1/2 W	151-1003-154J
R327	RESISTOR: fixed, composition, 1.5 megohms, ±5%, 1/2 W	151-1003-155J
R329	RESISTOR: fixed, composition, 1.5 megohms, ±5%, 1/2 W	151-1003-155J
R331	RESISTOR: fixed, composition, 2 megohms, ±5%, 1/2 W	151-1003-205J
R333	RESISTOR: fixed, composition, 4.7 megohms, ±5%, 1/2 W	151-1003-475J
R334	RESISTOR: fixed, composition, 2700 ohms, ±5%, 1/2 W	151-1003-272J
R335	RESISTOR: fixed, composition, 820 ohms, ±5%, 1 W	151-1004-821J
R339	RESISTOR: fixed, wirewound, 2000 ohms, ±5%, 20 W	556047-016
R340	RESISTOR: fixed, composition, 10,000 ohms, ±5%, 1/2 W	151-1003-103J
R341	RESISTOR: fixed, composition, 33,000 ohms, ±5%, 2 W	151-1005-333J
R343	RESISTOR: fixed, composition, 51,000 ohms, ±5%, 1/2 W	151-1003-513J
R345	RESISTOR: fixed, composition, 51,000 ohms, ±5%, 1/2 W	151-1003-513J

Ref. Desig.	Description	Singer Part No.
R346	RESISTOR: variable, 5 megohms, ±5%, 1/2 W	151-0001-017
R347	RESISTOR: variable, 100,000 ohms, 2 W	151-0007-025
R349	RESISTOR: fixed, composition, 1253 ohms, ±1%, 1/2 W	556029-155
R350	RESISTOR: fixed, composition, 8.23 ohms, ±1%, 1/2 W	151-1008-B8R23F
R351	RESISTOR: fixed, composition, 1253 ohms, ±1%, 1/2 W	556029-155
R352	RESISTOR: fixed, composition, 628 ohms ±1%, 1/2 W	151-1008-B6280F
R353	RESISTOR: fixed, composition, 16.8 ohms, ±1%, 1/2 W	151-1008-B16R8F
R354	RESISTOR: fixed, composition, 628 ohms, ±1%, 1/2 W	151-1008-B6280F
R355	RESISTOR: fixed, composition, 628 ohms, ±1%, 1/2 W	151-1008-B6280F
R356	RESISTOR: fixed, composition, 16.8 ohms, ±1%, 1/2 W	151-1008-B16R8F
R357	RESISTOR: fixed, composition, 628 ohms, ±1%, 1/2 W	151-1008-B6280F
R358	RESISTOR: fixed, composition, 253 ohms, ±1%, 1/2 W	151-1008-B2530F
R359	RESISTOR: fixed, composition, 43.8 ohms, ±1%, 1/2 W	151-1008-B43R8F
R360	RESISTOR: fixed, composition, 253 ohms, ±1%, 1/2 W	151-1008-B2530F
R361	RESISTOR: fixed, composition, 139 ohms, ±1%, 1/2 W	151-1008B1390F
R362	RESISTOR: fixed, composition, 102.5 ohms, ±1%, 1/2 W	556029-136
R363	RESISTOR: fixed, composition, 139 ohms, ±1%, 1/2 W	151-1008-B1390F
R364	RESISTOR: fixed, composition, 88 ohms, ±1%, 1/2 W	151-1008-B88ROF
R365	RESISTOR: fixed, composition, 356.4 ohms, ±1%, 1/2 W	556029-080
R366	RESISTOR: fixed, composition, 88 ohms, ±1%, 1/2 W	151-1008-B88ROF
R367	RESISTOR: variable, 10,000 ohms, 1/2 W	151-0001-011
R369	RESISTOR: variable, 1000 ohms, 2 W	151-0007-018
R401	RESISTOR: fixed, composition, 470 ohms, ±10%, 1/2 W	151-1003-471K
R403	RESISTOR: fixed, composition, 10,000 ohms, ±10%, 1/2 W	151-1003-103K
R405	(Refer to L401)	

Ref. Desig.	Description	Singer Part No.
R407	RESISTOR: fixed, composition, 39,000 ohms, ±10%, 2 W	151-1005-393K
R409	RESISTOR: fixed, composition, 680 ohms, ±10%, 1/4 W	151-1002-681K
R411	RESISTOR: fixed, composition, 91 ohms, ±10%, 1/4 W	151-1002-910K
R413	RESISTOR: variable, 1000 ohms, 1/2 W	151-0001-021
R601	RESISTOR: fixed, composition, 510,000 ohms, ±5%, 1/2 W	151-1003-514J
R603	RESISTOR: fixed, composition, 20,000 ohms, ±5%, 1/2 W	151-1003-203J
R604	RESISTOR: fixed, composition, 24 ohms, ±5%, 1/2 W	151-1003-240J
R605	RESISTOR: fixed, composition, 12,000 ohms, ±5%, 1/2 W	151-1003-123J
R606	RESISTOR: fixed, composition, 680 ohms, ±5%, 1/2 W	151-1003-681J
R607	RESISTOR: fixed, composition, 4300 ohms, ±5%, 1 W	151-1004-432J
R609	RESISTOR: fixed, composition, 24 ohms, ±5%, 1/2 W	151-1003-240J
R610	RESISTOR: fixed, composition, 100,000 ohms, ±5%, 1 W	151-1004-104J
R611	RESISTOR: fixed, composition, 510,000 ohms, ±5%, 1/2 W	151-1003-514J
R612	RESISTOR: fixed, composition, 24 ohms, ±5%, 1/2 W	151-1003-240J
R612(A)	RESISTOR: variable, linear, 3000 ohms, 2 W	151-0007-011
R613	RESISTOR: fixed, composition, 20,000 ohms ±5%, 1/2 W	151-1003-203J
R614	RESISTOR: fixed, composition, 12,000 ohms, ±5%, 1/2 W	151-1003-123J
R615	RESISTOR: fixed, composition, 680 ohms, ±5%, 1/2 W	151-1003-681J
R617	RESISTOR: fixed, composition, 24 ohms, ±5%, 1/2 W	151-1003-240J
R618	RESISTOR: fixed, composition, 4300 ohms, ±5%, 1 W	151-1004-432J
R619	RESISTOR: fixed, composition, 20,000 ohms, ±5%, 1/2 W	151-1003-203J
R620	RESISTOR: fixed, composition, 68 ohms, ±5%, 1/2 W	151-1003-680J
R621	RESISTOR: fixed, composition, 39,000 ohms, ±5%, 1/2 W	151-1003-393J
R622	RESISTOR: fixed, composition, 22,000 ohms, ±5%, 1/2 W	151-1003-223J
R623	RESISTOR: fixed, composition, 10,000 ohms, ±5%, 2 W	151-1005-103J

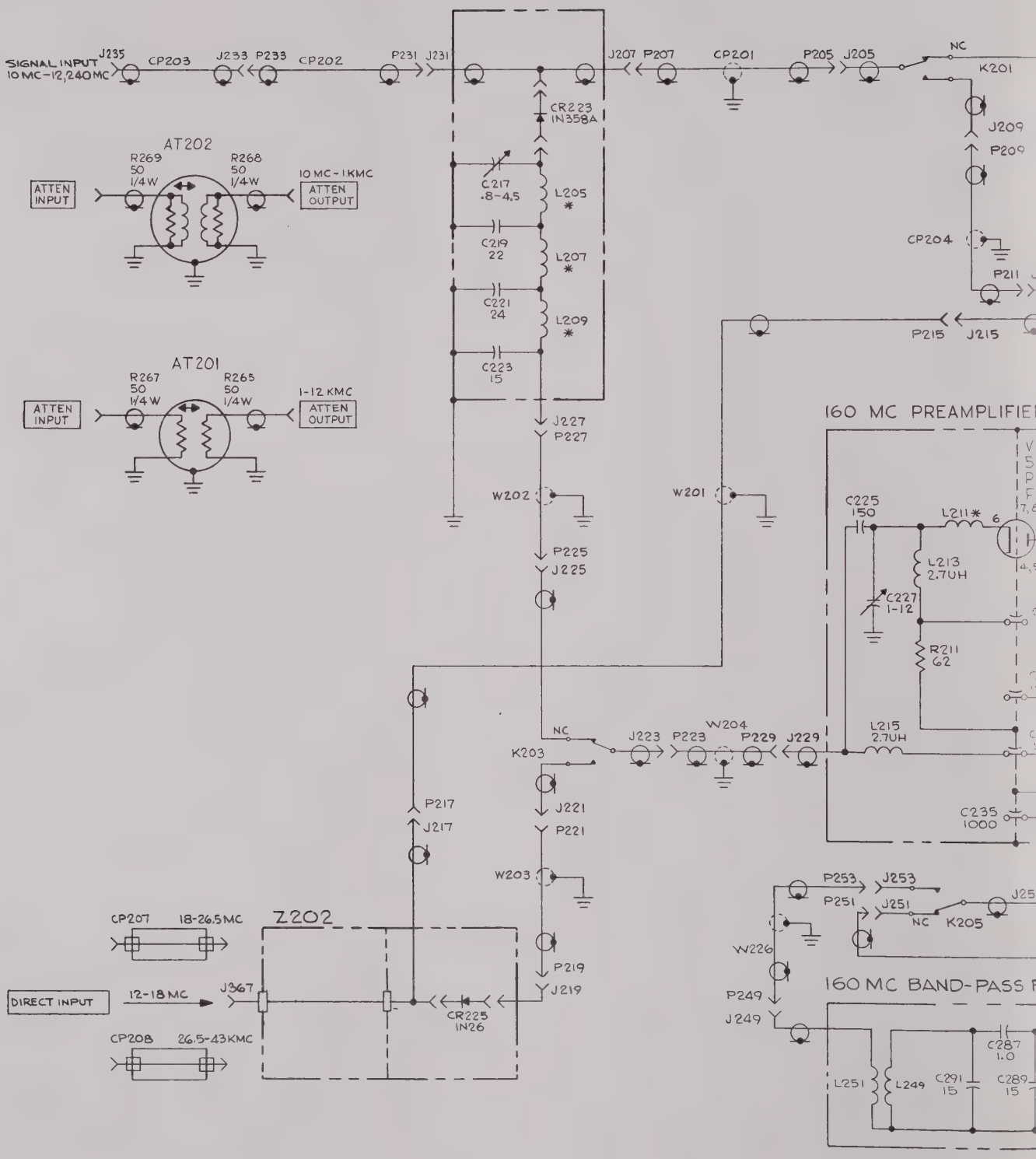
Ref. Desig.	Description	Singer Part No.
R624	RESISTOR: fixed, composition, 1000 ohms, ±5%, 1/2 W	151-1003-102J
R625	RESISTOR: (Factory selected; replace in kind.)	-----
R626	RESISTOR: fixed, composition, 100 ohms, ±5%, 1/2 W	151-1003-101J
R627	RESISTOR: fixed, composition, 1 megohm, ±5%, 1/2 W	151-1003-105J
R628	RESISTOR: fixed, composition, 100 ohms, ±5%, 1/2 W	151-1003-101J
R630	RESISTOR: fixed, composition, 240 ohms, ±5%, 1/2 W	151-1003-241J
R631	RESISTOR: variable, 100,000 ohms, 1/2 W	151-0001-023
R632	RESISTOR: fixed, composition, 62,000 ohms, ±5%, 1 W	151-1004-623J
R633	RESISTOR: fixed, composition, 180 ohms, ±5%, 1/2 W	151-1003-181J
R636	RESISTOR: fixed, composition, 100,000 ohms, ±5%, 1 W	151-1004-104J
R637	RESISTOR: variable, 5000 ohms, 1/2 W	151-0001-014
R638	RESISTOR: (Factory selected; replace in kind.)	-----
R639	RESISTOR: fixed, composition, 1 megohm, ±5%, 1/2 W	151-1003-105J
R640	RESISTOR: fixed, composition, 100 ohms, ±5%, 1/2 W	151-1003-101J
R642	RESISTOR: fixed, composition, 1000 ohms, ±5%, 1/2 W	151-1003-102J
R643	RESISTOR: fixed, composition, 100 ohms, ±5%, 1/2 W	151-1003-101J
R644	RESISTOR: fixed, composition, 62,000 ohms, ±5%, 1 W	151-1004-623J
R645	RESISTOR: fixed, composition, 240 ohms, ±5%, 1 W	151-1003-241J
R646	RESISTOR: variable, 100,000 ohms, 1/2 W	151-0001-023
R647	RESISTOR: fixed, composition, 180 ohms, ±5%, 1/2 W	151-1003-181J
R649	RESISTOR: fixed, composition, 12,000 ohms, ±5%, 1 W	151-1004-123J
R650	RESISTOR: variable, 50,000 ohms, 2 W	151-0007-014
R651	RESISTOR: fixed, composition, 100 ohms, ±5%, 1/2 W	151-1003-101J
R652	RESISTOR: fixed, composition, 51,000 ohms, ±5%, 1/2 W	151-1003-513J
R653	RESISTOR: fixed, composition, 10,000 ohms, ±5%, 1 W	151-1004-103J
R654	RESISTOR: fixed, composition, 33 ohms, ±5%, 1/2 W	151-1003-330J
R655	RESISTOR: fixed, composition, 130 ohms, ±5%, 1/2 W	151-1003-131J
R656	RESISTOR: fixed, composition, 1000 ohms, ±5%, 1/2 W	151-1003-102J
R657	RESISTOR: variable, 1000 ohms, 1/2 W	151-0001-010
R658	RESISTOR: fixed, composition, 100,000 ohms, ±5%, 1/2 W	151-1003-104J
R659	RESISTOR: variable, 100,000 ohms, 1/2 W	151-0001-018
R661	RESISTOR: fixed, composition, 68,000 ohms, ±5%, 1/2 W	151-1003-683J
R662	RESISTOR: fixed, composition, 8200 ohms, ±5%, 1/2 W	151-1003-822J
R663	RESISTOR: fixed, wirewound, 11,000 ohms, ±1%, 5 W	556054-006
R665	RESISTOR: fixed, wirewound, 11,000 ohms, ±1%, 5 W	556054-006
R666	RESISTOR: fixed, composition, 100 ohms, ±5%, 1/2 W	151-1003-101J
R667	RESISTOR: variable, 5 megohm, 2 W	556056-005
R669	RESISTOR: fixed, wirewound, 11,000 ohms, ±1%, 5 W	556054-006
R670	RESISTOR: fixed, composition, 100 ohms, ±5%, 1/2 W	151-1003-101J
R671	RESISTOR: variable, 10,000 ohms, 1/2 W	151-0001-011
R672	RESISTOR: fixed, composition, 100 ohms, ±5%, 1/2 W	151-1003-101J
R673	RESISTOR: fixed, composition, 130,000 ohms, ±5%, 1/2 W	151-1003-134J
R674	RESISTOR: fixed, composition, 100,000 ohms, ±5%, 1/2 W	151-1003-104J
R675	RESISTOR: fixed, composition, 91,000 ohms, ±5%, 1/2 W	151-1003-913J
R677	RESISTOR: fixed, composition, 30,000 ohma, ±5%, 1 W	151-1004-303J
R679	RESISTOR: fixed, composition, 33,000 ohms, ±5%, 1/2 W	151-1003-333J
R680	RESISTOR: fixed, composition, 150,000 ohms, ±5%, 1/2 W	151-1003-154J
R681	RESISTOR: variable, 5000 ohms, 1/2 W	151-0001-014

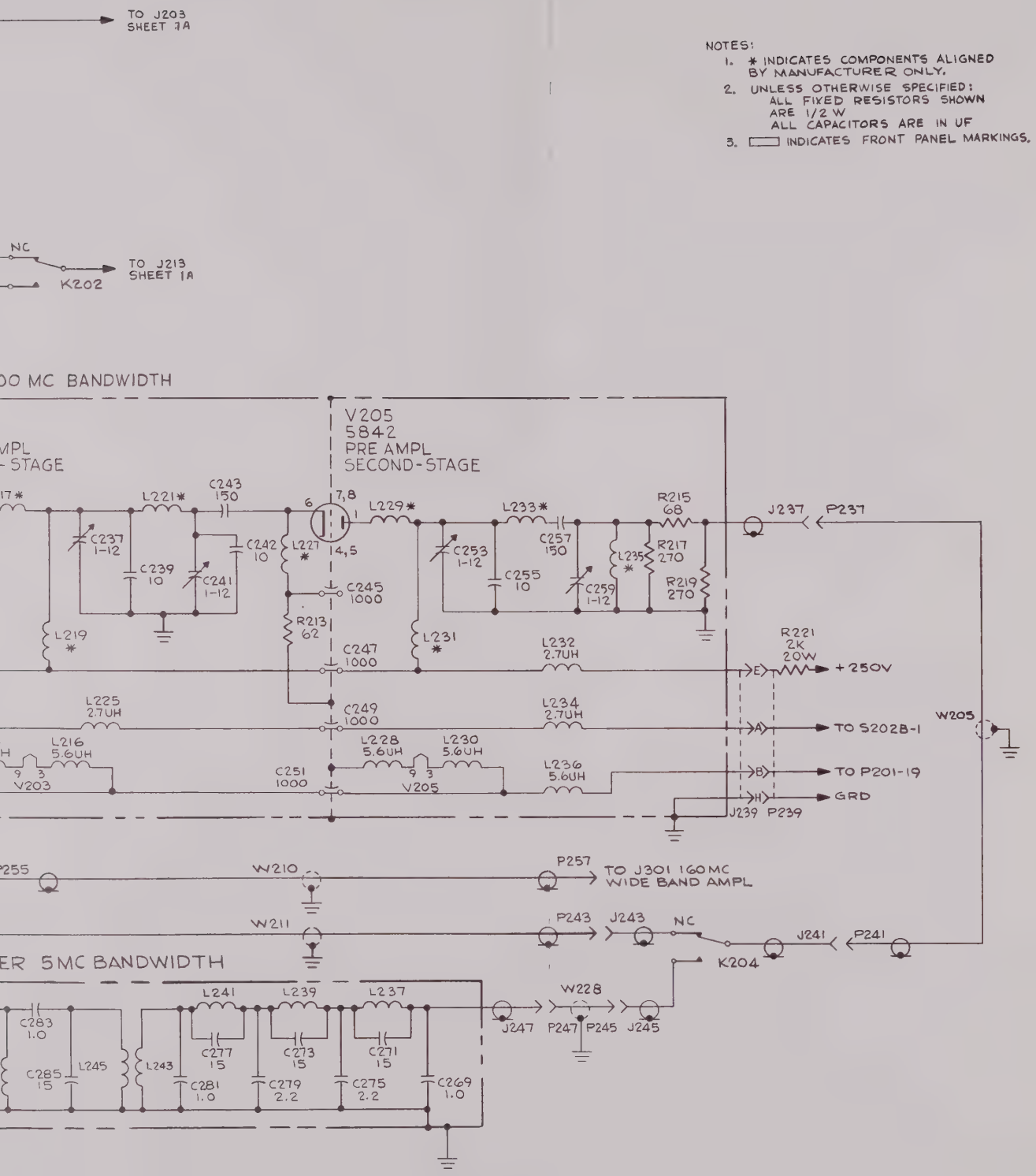
Ref. Desig.	Description	Singer Part No.
R682	RESISTOR: fixed, composition, 100,000 ohms, ±5%, 1/2 W	151-1003-104J
R683	RESISTOR: fixed, composition, 820 ohms, ±5%, 1/2 W	151-1003-821J
R684	RESISTOR: fixed, composition, 360,000 ohms ±5%, 1/2 W	151-1003-364J
R685	RESISTOR: fixed, composition, 100,000 ohms, ±5%, 1/2 W	151-1003-104J
R686	RESISTOR: variable, 50,000 ohms, 2 W	151-0007-014
R687	RESISTOR: fixed, composition, 51,000 ohms, ±5%, 1/2 W	151-1003-513J
R689	RESISTOR: fixed, composition, 100,000 ohms, ±5%, 1/2 W	151-1003-104J
R690	RESISTOR: fixed, composition, 56,000 ohms, ±5%, 1/2 W	151-1003-563J
R691	RESISTOR: fixed, composition, 470,000 ohms, ±±5%, 1/2 W	151-1003-474J
R693	RESISTOR: fixed, composition, 300,000 ohms, ±5%, 1/2 W	151-1003-304J
R694	RESISTOR: fixed, composition, 3600 ohms, ±5%, 1/2 W	151-1003-362J
R697	RESISTOR: fixed, composition, 27,000 ohms, ±5%, 1/2 W	151-1003-273J
R698	RESISTOR: fixed, composition, 10,000 ohms, ±5%, 2 W	151-1005-113J
R699	RESISTOR: fixed, composition, 10,000 ohms, ±5%, 1/2 W	151-1003-103J
R701	RESISTOR: fixed, composition, 5.1 megohms, ±5%, 2 W	151-1005-515J
R703	RESISTOR: fixed, composition, 5.1 megohms, ±5%, 2 W	151-1005-515J
R705	RESISTOR: variable, 5 megohms, 2 W	556162-688
R707	RESISTOR: fixed, composition, 3 megohms, ±5%, 1 W	151-1004-305J
R709	RESISTOR: variable, 1 megohm, 2 W	556162-687
R711	RESISTOR: fixed, composition, 1.5 megohms, ±5%, 1/2 W	151-1003-155J
R713	RESISTOR: fixed, composition, 200,000 ohms, ±5%, 1/2 W	151-1003-204J
R801	RESISTOR: fixed, composition, 470 ohms, ±5%, 1/2 W	151-1003-471J
R803	RESISTOR: fixed, composition, 1 megohm, ±5%, 1/2 W	151-1003-105J
R805	RESISTOR: fixed, composition, 220,000 ohms, ±5%, 1/2 W	151-1003-224J
R807	RESISTOR: fixed, composition, 100,000 ohms, ±5%, 1/2 W	151-1003-104J

Ref. Desig.	Description	Singer Part No.
R809	RESISTOR: fixed, composition, 39,000 ohms, ±5%, 1/2 W	151-1003-393J
R810	RESISTOR: fixed, composition, 1000 ohms, ±5%, 1/2 W	151-1003-102J
R811	RESISTOR: fixed, composition, 1 megohm, ±5%, 1/2 W	151-1003-105J
R813	RESISTOR: fixed, composition, 100 ohms, ±5%, 1/2 W	151-1003-101J
R814	RESISTOR: fixed, composition, 3000 ohms, ±5%, 1/2 W	151-1003-302J
R815	RESISTOR: variable, 50,000 ohms, 2 W	556052-036
R817	RESISTOR: fixed, composition, 10,000 ohms, ±5%, 1/2 W	151-1003-103J
R819	RESISTOR: fixed, composition, 100,000 ohms, ±5%, 1 W	151-1004-104J
R821	RESISTOR: fixed, composition, 470,000 ohms, ±5%, 1/2 W	151-1003-474J
R823	RESISTOR: fixed, composition, 820,000 ohms, ±5%, 1/2 W	151-1003-824J
R825	RESISTOR: variable, dual, 5 meg/50K, 2 W	556057-004
R827	RESISTOR: fixed, composition, 2400 ohms, ±5%, 1/2 W	151-1003-242J
R831	RESISTOR: fixed, composition, 100,000 ohms, ±5%, 1/2 W	151-1004-104J
R833	RESISTOR: fixed, composition, 18,000 ohms, ±5%, 1 W	151-1004-183J
R835	RESISTOR: fixed, composition, 15,000 ohms, ±5%, 1 W	151-1004-153J
R837	RESISTOR: variable, miniature, 5 megohms, 1/2 W	151-0001-017
R839	RESISTOR: fixed, composition, 4.7 megohms, ±5%, 1/2 W	151-1003-475J
R840	RESISTOR: fixed, composition, 2 megohms, ±5%, 1/2 W	151-1003-205J
R841	RESISTOR: fixed, composition, 220,000 ohms, ±5%, 1/2 W	151-1003-224J
R843	RESISTOR: fixed, composition, 100,000 ohms, ±5%, 1 W	151-1004-104J
R845	RESISTOR: fixed, composition, 2.2 megohms, ±5%, 1/2 W	151-1003-225J
R847	RESISTOR: variable, 5000 ohms, 1/2 W	151-0001-014
R849	RESISTOR: fixed, composition, 1000 ohms, ±5%, 1/2 W	151-1003-102J
R851	RESISTOR: fixed, composition, 1.8 megohms, ±5%, 1/2 W	151-1003-185J
R853	RESISTOR: fixed, composition, 220,000 ohms, ±5%, 1/2 W	151-1003-224J

Ref. Desig.	Description	Singer Part No.
R855	RESISTOR: fixed, composition, 75,000 ohms, ±5%, 2 W	151-1005-753J
R857	RESISTOR: fixed, composition, 180,000 ohms, ±5%, 1/2 W	151-1003-184J
R859	RESISTOR: fixed, composition, 5600 ohms, ±5%, 1/2 W	151-1003-562J
R860	RESISTOR: fixed, composition, 4.7 megohms, ±5%, 1/2 W	151-1003-475J
R861	RESISTOR: variable, 10,000 ohms, 2 W	151-0007-006
R863	RESISTOR: variable, dual, 2 meg/2 meg, 2 W	556057-008
R865	RESISTOR: variable, 500,000 ohms, 2 W	151-0007-015
R867	RESISTOR: variable, 10,000 ohms, 2 W	151-0007-006
R871	RESISTOR: variable, 5 megohms, 2 W	151-0007-004
R873	RESISTOR: fixed, composition, 200,000 ohms, ±5%, 1/2 W	151-1003-204J
R901	RESISTOR: fixed, composition, 100,000 ohms, ±5%, 1/2 W	151-1003-104J
R902	RESISTOR: fixed, composition, 3900 ohms, ±5%, 1 W	151-1004-392J
R903	RESISTOR: fixed, composition, 51 ohms, ±5%, 1/2 W	151-1003-510J
R905	RESISTOR: fixed, composition, 51 ohms, ±5%, 1/2 W	151-1003-510J
R907	RESISTOR: fixed, composition, 100,000 ohms, ±5%, 1/2 W	151-1003-104J
R909	RESISTOR: fixed, composition, 20,000 ohms, ±5%, 1/2 W	151-1003-203J
R911	RESISTOR: fixed, composition, 20,000 ohms, ±5%, 1/2 W	151-1003-203J
R912	RESISTOR: fixed, composition, 1 megohm, ±5%, 1/2 W	151-1003-105J
R913	RESISTOR: fixed, composition, 51 ohms, ±5%, 1/2 W	151-1003-510J
R915	RESISTOR: fixed, composition, 13,000 ohms, ±5%, 2 W	151-1005-133J
R917	RESISTOR: fixed, composition, 6200 ohms, ±5%, 2 W	151-1005-622J
R919	RESISTOR: fixed, composition, 47,000 ohms, ±5%, 1 W	151-1004-473J
R921	RESISTOR: fixed, composition, 30,000 ohms, ±5%, 1/2 W	151-1003-303J
R923	RESISTOR: fixed, composition, 51 ohms, ±5%, 1/2 W	151-1003-510J
R925	RESISTOR: fixed, compositon, 22,000 ohms, ±5%, 1/2 W	151-1003-223J
R929	RESISTOR: fixed, composition, 75 ohms, ±5%, 1/2 W	151-1003-750J
R931	RESISTOR: fixed, composition, 33,000 ohms ±5%, 1/2 W	151-1003-333J
R933	RESISTOR: fixed, composition, 18,000 ohms, ±5%, 1/2 W	151-1003-183J
R935	RESISTOR: fixed, composition, 18,000 ohms, ±5%, 1/2 W	151-1003-183J
R937	RESISTOR: fixed, composition, 510 ohms, ±5%, 1/2 W	151-1003-511J
R939	RESISTOR: variable, 25,000 ohms, ±10%, 2 W	151-0007-023
RV337	VARISTOR:	556052-059
S201	SWITCH: range	556019-207
S202	SWITCH: meter	556019-206
S203	SWITCH: micro	556019-023
S301	SWITCH: toggle, DPDT, miniature	556019-144
S302	SWITCH: toggle, DPDT, miniature	556019-144
S303	SWITCH: toggle, DPDT, miniature	556019-144
S304	SWITCH: toggle, DPDT, miniature	556019-144
S305	SWITCH: toggle, DPDT, miniature	556019-144
S306	SWITCH: toggle, DPDT, miniature	556019-144
S401	SWITCH: micro	556019-057
S601	SWITCH: rotary, miniature	556019-086
S901	SWITCH: assembly	556162-261
T101	TRANSFORMER:	556020-117
T102	TRANSFORMER:	556020-116
T103	COIL: RF	556026-238
T201	TRANSFORMER: filament	556020-135
V101	ELECTRON TUBE: 6550	556027-163
V102	ELECTRON TUBE: 6550	556027-163
V103	ELECTRON TUBE: 6550	556027-163
V104	ELECTRON TUBE: 12AX7A	556027-228
V105	ELECTRON TUBE: OG3/85A2	556027-012
V106	ELECTRON TUBE: 12AX7A	556027-228
V107	ELECTRON TUBE: OA2	556027-003
V108	ELECTRON TUBE: 6550	556027-163

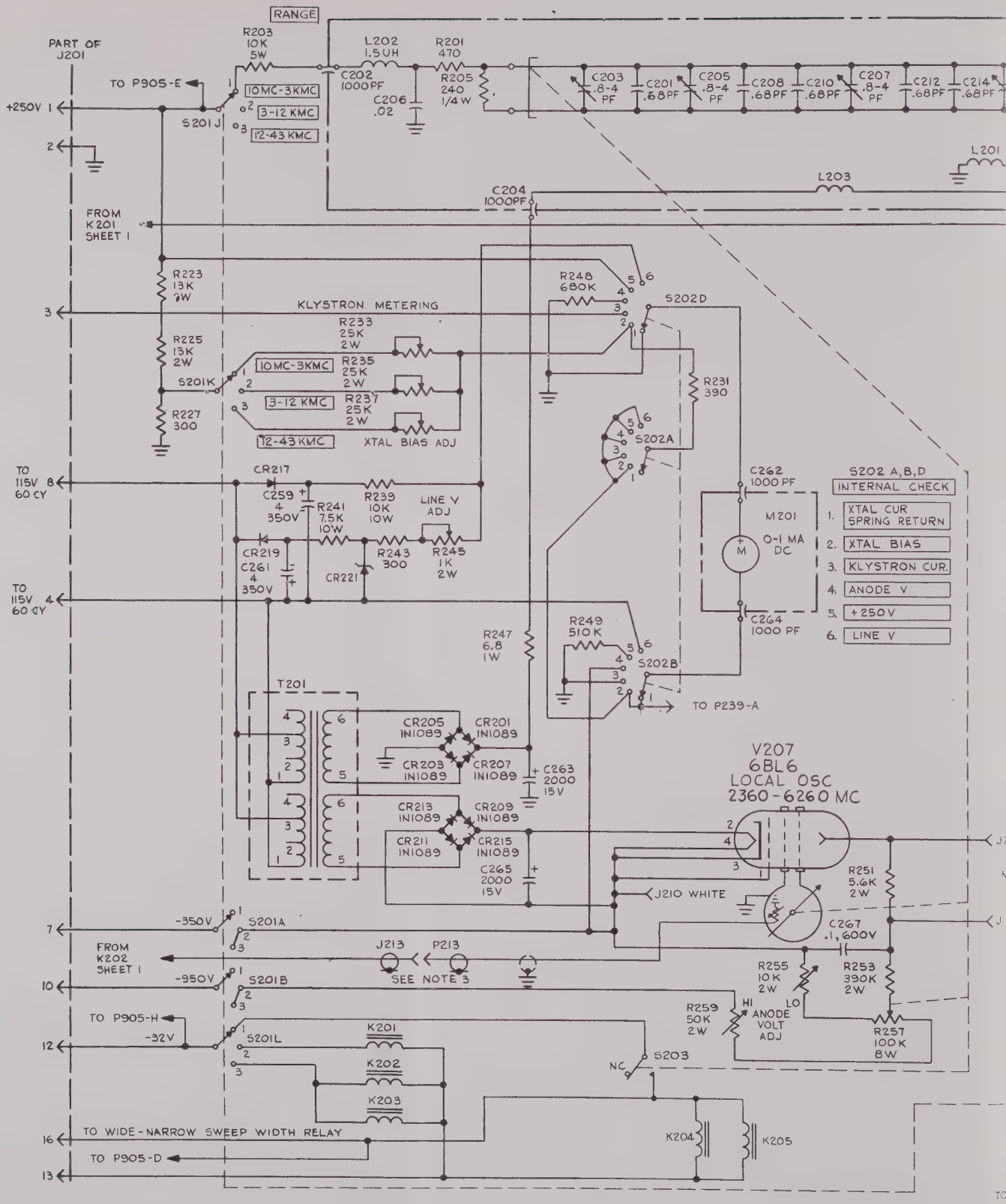
Ref. Desig.	Description	Singer Part No.
V109	ELECTRON TUBE: 6AH6	556027-067
V110	ELECTRON TUBE: OD3	556027-010
V111	ELECTRON TUBE: OD3	556027-010
V112	ELECTRON TUBE: OD3	556027-010
V113	ELECTRON TUBE: OD3	556027-010
V114	ELECTRON TUBE: 6BQ5	556027-157
V201	ELECTRON TUBE: 6AF4A	556027-066
V203	ELECTRON TUBE: 5842	556027-057
V205	ELECTRON TUBE: 5842	556027-057
V207	ELECTRON TUBE: 6BL6	556027-159
V301	ELECTRON TUBE: 5842	556027-057
V302	ELECTRON TUBE: 5842	556027-057
V303	ELECTRON TUBE: 6AF4A	556027-066
V304	ELECTRON TUBE: 12AX7	556027-174
V305	ELECTRON TUBE: 12AX7	556027-174
V306	ELECTRON TUBE: 6AQ5A	556027-158
V307	ELECTRON TUBE: 6AF4A	556027-066
V401	ELECTRON TUBE: 6AF4A	556027-066
V601	ELECTRON TUBE: 6688	556027-134
V602	ELECTRON TUBE: 6688	556027-134
V603	ELECTRON TUBE: 6J6	556027-101
V604	ELECTRON TUBE: 6AB4	556027-064
V605	ELECTRON TUBE: 6BJ6	556027-200
V606	ELECTRON TUBE: 6AB4	556027-064
V607	ELECTRON TUBE: 6BJ6	556027-200
V608	ELECTRON TUBE: 6AH7	556027-067
V609	ELECTRON TUBE: 6AL5	556027-071
V610	ELECTRON TUBE: SD504	556027-188
V611	ELECTRON TUBE: 12AU7A	556027-171
V612	ELECTRON TUBE: 6CB6A	556027-160
V701	ELECTRON TUBE: 5ADP1 (CRT)	556027-036
V801	ELECTRON TUBE: 12AT7	556027-017
V802	ELECTRON TUBE: 6CB6A	556027-160
V803	ELECTRON TUBE: 6AB4	556027-064
V804	ELECTRON TUBE: 12AU7A	556027-171
V901	ELECTRON TUBE: 6922	556027-135
V902	ELECTRON TUBE: 6CB6A	556027-160
V903	ELECTRON TUBE: 12BY7A	556027-026
Y901	CRYSTAL: 10mc	556027-060
Y902	CRYSTAL: 1mc	556025-069
Y903	CRYSTAL: 100 mc,	556025-061
Z601	COIL: IF	556026-214
Z603	COIL: IF	556026-214
Z605	COIL: IF	556026-214
Z607	COIL: IF	556026-223

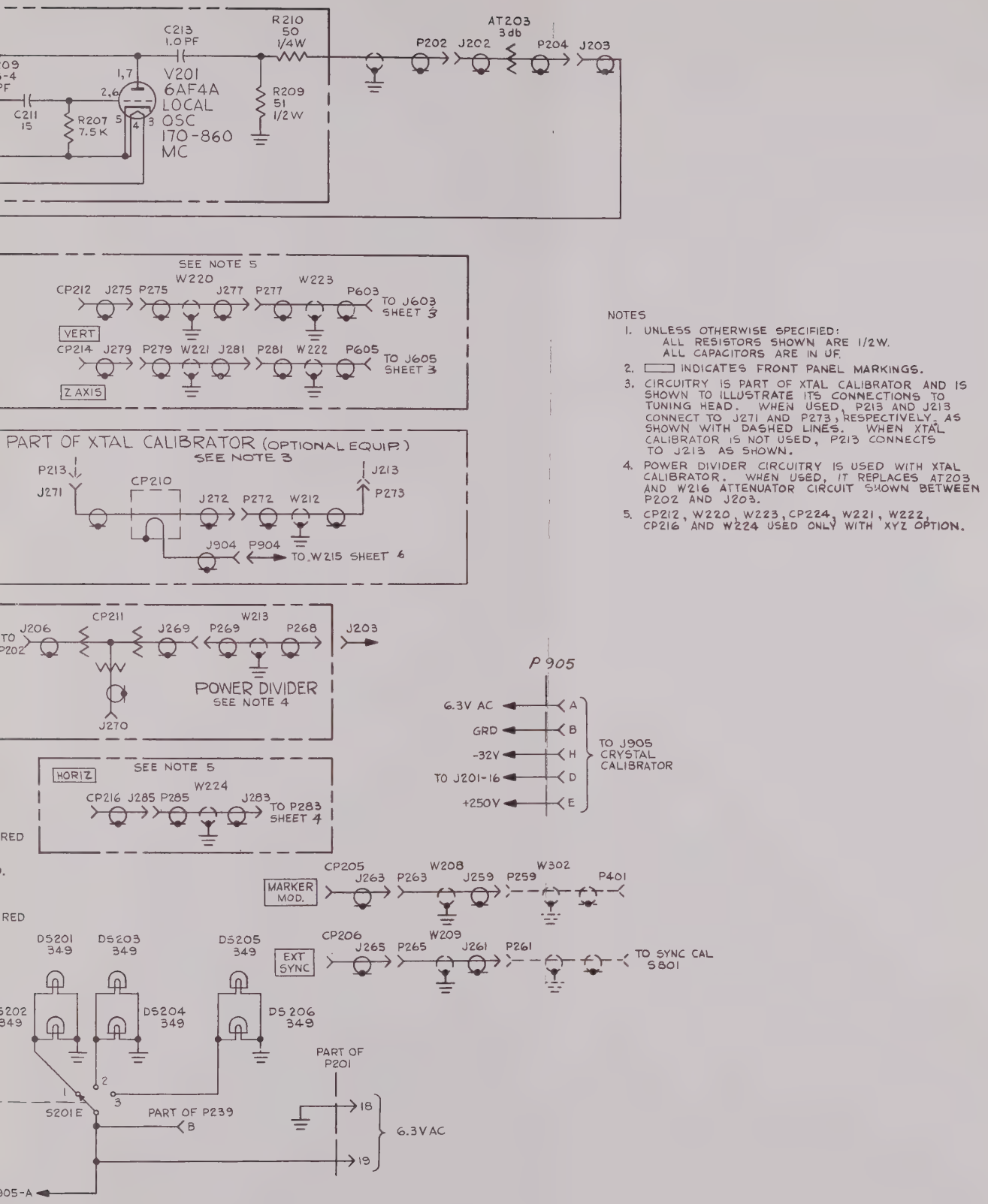

SIGNAL INPUT
10 MC-12,240 MC
J235
CP203
J233
P233
CP202
P231
J231
J207
P207
CP201
P205
J205
NC
K201
J209
P209
CP204
P211
P215
J215
CR223
IN358A
C217
.8-4.5
L205
C219
22
L207
C221
24
L209
C223
15
AT202
R269
50
1/4W
R268
50
1/4W
ATTEN
INPUT
10 MC-1 KMC
ATTEN
OUTPUT
AT201
R267
50
1/4W
R265
50
1/4W
ATTEN
INPUT
1-12 KMC
ATTEN
OUTPUT
J227
P227
W202
W201
160 MC PREAMPLIFIE
C225
150
L211*
6
L213
2.7UH
C227
1-12
R211
62
P225
J225
NC
K203
J223
P223
W204
P229
J229
L215
2.7UH
C235
1000
P217
J217
J221
P221
W203
P219
J219
P253
J253
P251
J251
NC
K205
W226
P249
J249
160 MC BAND-PASS
C287
1.0
L251
L249
C291
15
C289
15
CP207
18-26.5 MC
Z202
DIRECT INPUT
12-18 MC
J367
CR225
IN26
CP208
26.5-43 KMC



556155-281 12 (Sheet 1)

Figure 7-1. Tuning Head, Schematic Diagram


RANGE
PART OF J201
TO P905-E
+250V 1
2
S201J
10MC-3KMC
3-12 KMC
12-43 KMC
R203 10K 5W
L202 1.5 UH
C202 1000PF
C206 .02
R201 470
R205 240 1/4 W
C203 .8-4 PF
C201 .68PF
C205 .8-4 PF
C208 .68PF
C210 .68PF
C207 .8-4 PF
C212 .68PF
C214 .68PF
L201
L203
C204 1000PF
FROM K201 SHEET 1
R223 13K 2W
3
KLYSTRON METERING
R225 13K 2W
S201K
R227 300
R233 25K 2W
R235 25K 2W
R237 25K 2W
XTAL BIAS ADJ
R248 680K
S202D
R231 390
S202A
TO 115V 60 CY 8
CR217
C259 4 350V
R241 7.5K 10W
R239 10K 10W
LINE V ADJ
CR219
C261 4 350V
CR221
R243 300
R245 1K 2W
TO 115V 60 CY 4
C262 1000 PF
M201
0-1 MA DC
C264 1000 PF
S202 A,B,D
INTERNAL CHECK
1. XTAL CUR SPRING RETURN
2. XTAL BIAS
3. KLYSTRON CUR.
4. ANODE V
5. +250V
6. LINE V
R247 6.8 1W
R249 510K
S202B
TO P239-A
T201
CR205 IN1089
CR201 IN1089
CR203 IN1089
CR207 IN1089
C263 2000 15V
CR213 IN1089
CR209 IN1089
CR211 IN1089
CR215 IN1089
C265 2000 15V
V207 6BL6 LOCAL OSC 2360-6260 MC
J210 WHITE
R251 5.6K 2W
C267 .1, 600V
R255 10K 2W
R253 390K 2W
R259 50K 2W
HI ANODE VOLT ADJ LO
R257 100K 8W
7
-350V
S201A
FROM K202 SHEET 1
J213
P213
SEE NOTE 3
10
-950V
S201B
TO P905-H
-32V
12
S201L
K201
K202
K203
S203
NC
16
TO WIDE-NARROW SWEEP WIDTH RELAY
TO P905-D
13
K204
K205

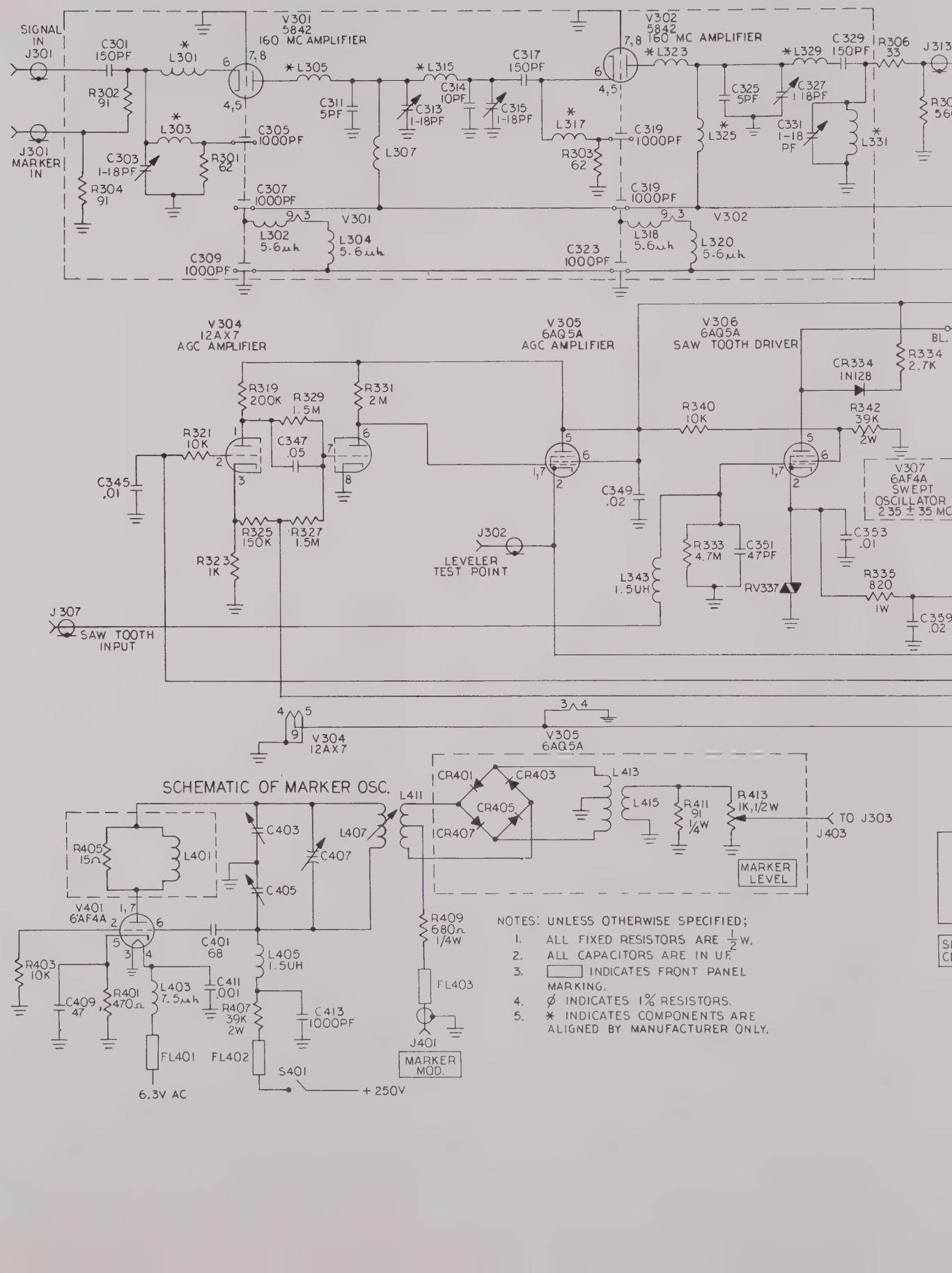


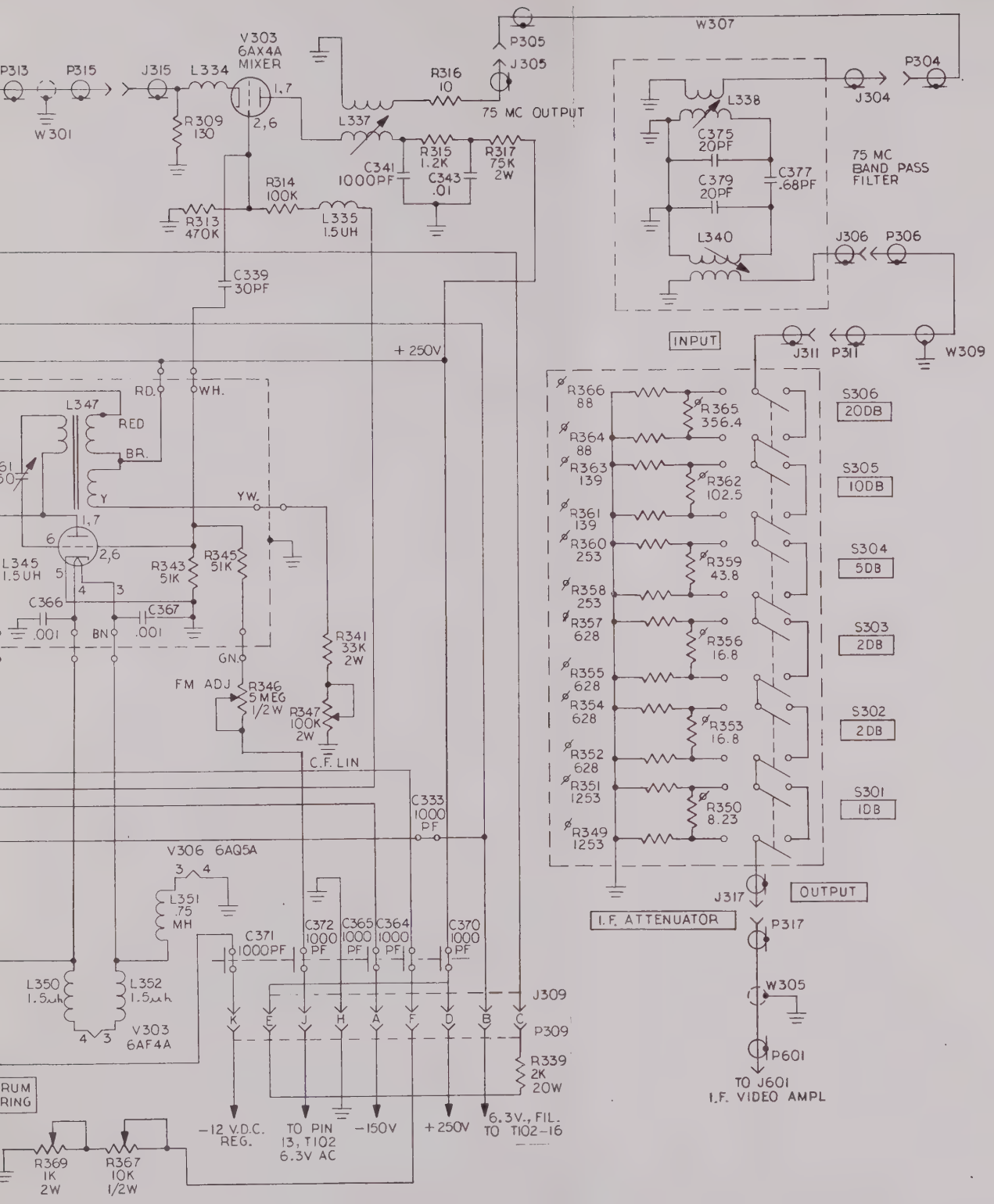
NOTES

1. UNLESS OTHERWISE SPECIFIED:
   ALL RESISTORS SHOWN ARE 1/2W.
   ALL CAPACITORS ARE IN UF.
2. ▭ INDICATES FRONT PANEL MARKINGS.
3. CIRCUITRY IS PART OF XTAL CALIBRATOR AND IS SHOWN TO ILLUSTRATE ITS CONNECTIONS TO TUNING HEAD. WHEN USED, P213 AND J213 CONNECT TO J271 AND P273, RESPECTIVELY, AS SHOWN WITH DASHED LINES. WHEN XTAL CALIBRATOR IS NOT USED, P213 CONNECTS TO J213 AS SHOWN.
4. POWER DIVIDER CIRCUITRY IS USED WITH XTAL CALIBRATOR. WHEN USED, IT REPLACES AT203 AND W216 ATTENUATOR CIRCUIT SHOWN BETWEEN P202 AND J203.
5. CP212, W220, W223, CP224, W221, W222, CP216 AND W224 USED ONLY WITH XYZ OPTION.

556155-281 12 (Sheet 1A)

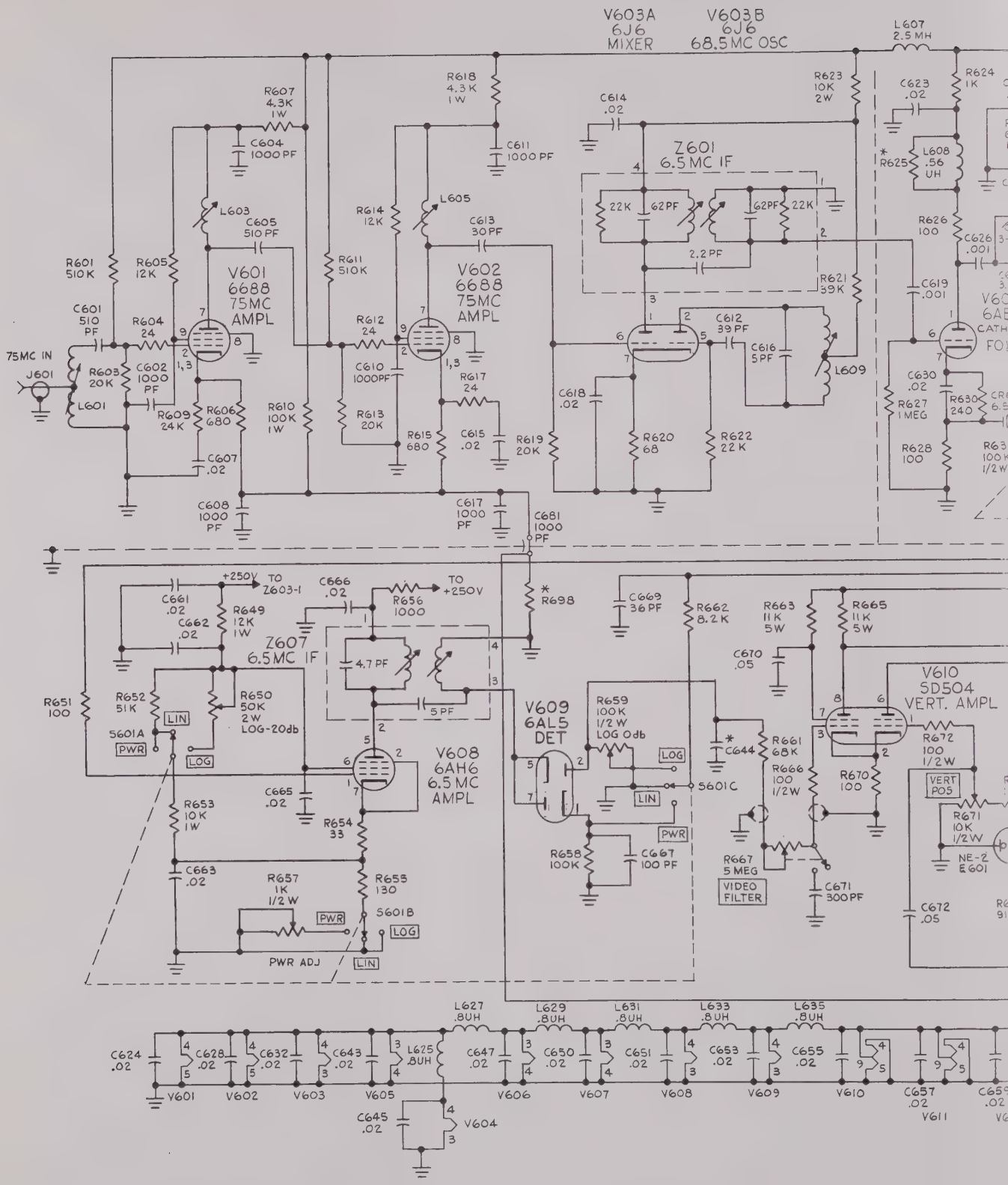
Figure 7-2. Tuning Head, Schematic Diagram

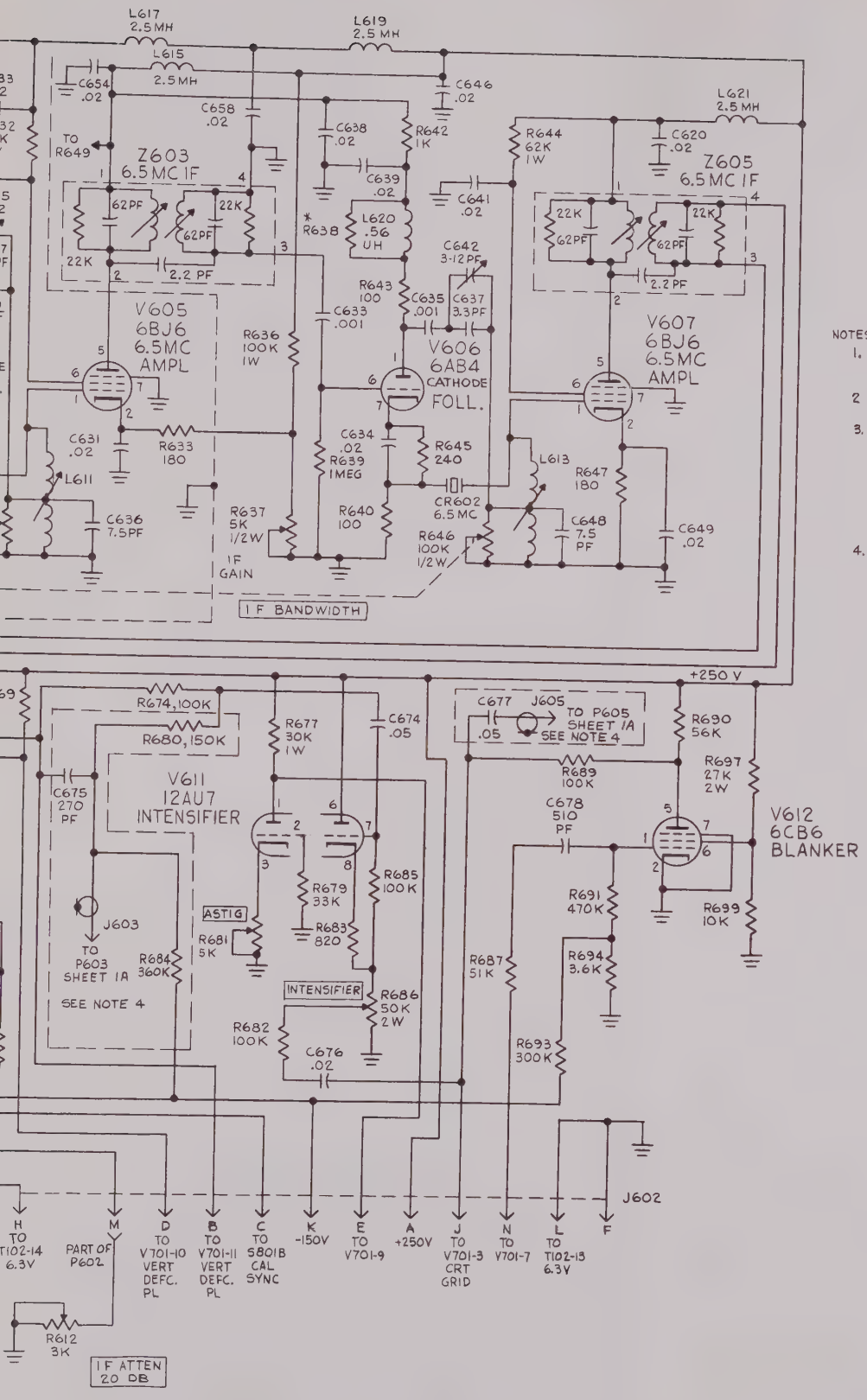

SIGNAL IN J301
J301 MARKER IN
C301 150PF
L301
R302 91
R304 91
L303
C303 1-18PF
R301 62
C305 1000PF
C307 1000PF
C309 1000PF
V301 5842 160 MC AMPLIFIER
L302 5.6μh
L304 5.6μh
C311 5PF
L305
L307
C313 1-18PF
C314 10PF
L315
C315 1-18PF
C317 150PF
L317
R303 62
C319 1000PF
C323 1000PF
V302 5842 160 MC AMPLIFIER
L318 5.6μh
L320 5.6μh
L323
L325
C325 5PF
C327 1-18PF
L329
C329 150PF
C331 1-18 PF
L331
R306 33
V304 12AX7 AGC AMPLIFIER
V305 6AQ5A AGC AMPLIFIER
V306 6AQ5A SAW TOOTH DRIVER
R319 200K
R329 1.5M
R331 2M
R321 10K
C347 .05
C345 .01
R325 150K
R327 1.5M
R323 1K
J302 LEVELER TEST POINT
J307 SAW TOOTH INPUT
R340 10K
R342 39K 2W
CR334 1N128
R334 2.7K
C349 .02
R333 4.7M
C351 47PF
L343 1.5UH
RV337
C353 .01
R335 820 1W
C359 .02
V307 6AF4A SWEPT OSCILLATOR 235 ± 35 MC
SCHEMATIC OF MARKER OSC.
V401 6AF4A
R405 15Ω
L401
C403
C405
C407
L407
L411
CR401
CR403
CR405
CR407
L413
L415
R411 91 1/4W
R413 1K, 1/2W
TO J303
J403
MARKER LEVEL
R403 10K
C409 47
R401 470Ω
L403 7.5μh
C401 68
L405 1.5UH
C411 .001
R407 39K 2W
C413 1000PF
R409 680Ω 1/4W
FL403
J401
MARKER MOD.
FL401
FL402
S401
6.3V AC
+ 250V
NOTES: UNLESS OTHERWISE SPECIFIED;
1. ALL FIXED RESISTORS ARE 1/2 W.
2. ALL CAPACITORS ARE IN U.F.
3. ▭ INDICATES FRONT PANEL MARKING.
4. ø INDICATES 1% RESISTORS.
5. * INDICATES COMPONENTS ARE ALIGNED BY MANUFACTURER ONLY.



556155-281 12 (Sheet 2)

Figure 7-3. Wideband I.F. Amplifier and Marker, Schematic Diagram


V603A 6J6 MIXER
V603B 6J6 68.5MC OSC
L607 2.5 MH
R607 4.3K 1W
C604 1000 PF
R618 4.3K 1W
C611 1000 PF
C614 .02
R623 10K 2W
C623 .02
R624 1K
Z601 6.5 MC IF
22K 62PF 62PF 22K
2.2 PF
L608 .56 UH
R625
L603
C605 510 PF
L605
R614 12K
C613 30PF
R626 100
C626 .001
R601 510K
R605 12K
R611 510K
V601 6688 75MC AMPL
V602 6688 75MC AMPL
R621 39K
C619 .001
C601 510 PF
R604 24
R612 24
C612 39 PF
C616 5PF
L609
75MC IN
J601
R603 20K
C602 1000 PF
L601
C610 1000PF
R617 24
C618 .02
C630 .02
R627 1 MEG
R630 240
R609 24K
R606 680
R610 100K 1W
R613 20K
R615 680
C615 .02
R619 20K
R620 68
R622 22K
R628 100
C607 .02
C608 1000 PF
C617 1000 PF
C681 1000 PF
+250V
TO Z603-1
C666 .02
TO +250V
R656 1000
*R698
C669 36 PF
R662 8.2K
R663 11K 5W
R665 11K 5W
C661 .02
C662 .02
R649 12K 1W
Z607 6.5MC IF
4.7 PF
5 PF
C670 .05
V610 5D504 VERT. AMPL
R651 100
R652 51K
R650 50K 2W LOG-20db
LIN
S601A
PWR
LOG
V608 6AH6 6.5 MC AMPL
V609 6AL5 DET
R659 100K 1/2W LOG 0db
*C644
R661 68K
R672 100 1/2W
R666 100 1/2W
R670 100
VERT POS
C665 .02
R653 10K 1W
R654 33
R658 100K
C667 100 PF
S601C
R671 10K 1/2W
NE-2 E601
R667 5 MEG
VIDEO FILTER
C671 300PF
C672 .05
R657 1K 1/2 W
R655 130
S601B
PWR ADJ
L627 .8UH
L629 .8UH
L631 .8UH
L633 .8UH
L635 .8UH
C624 .02
C628 .02
C632 .02
C643 .02
L625 .8UH
C647 .02
C650 .02
C651 .02
C653 .02
C655 .02
C645 .02
V601
V602
V603
V605
V606
V607
V608
V609
V610
V604
C657 .02
V611



NOTES:

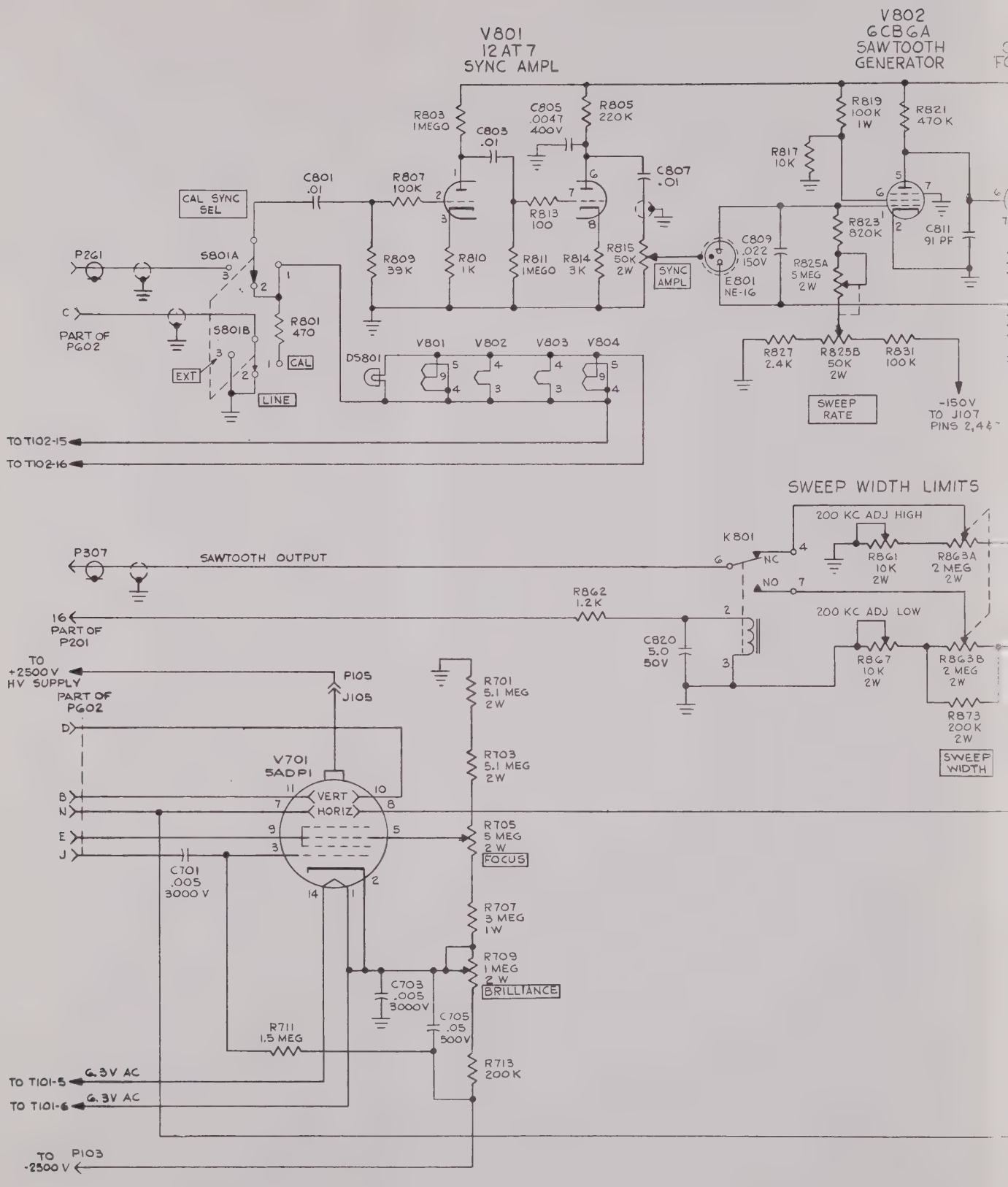
1. UNLESS OTHERWISE SPECIFIED: ALL RESISTORS ARE 1/2 WATT ALL CAPACITORS ARE IN UF
2. ☐ INDICATES MARKING ON FRONT PANEL
3. * INDICATES FACTORY ADJUST

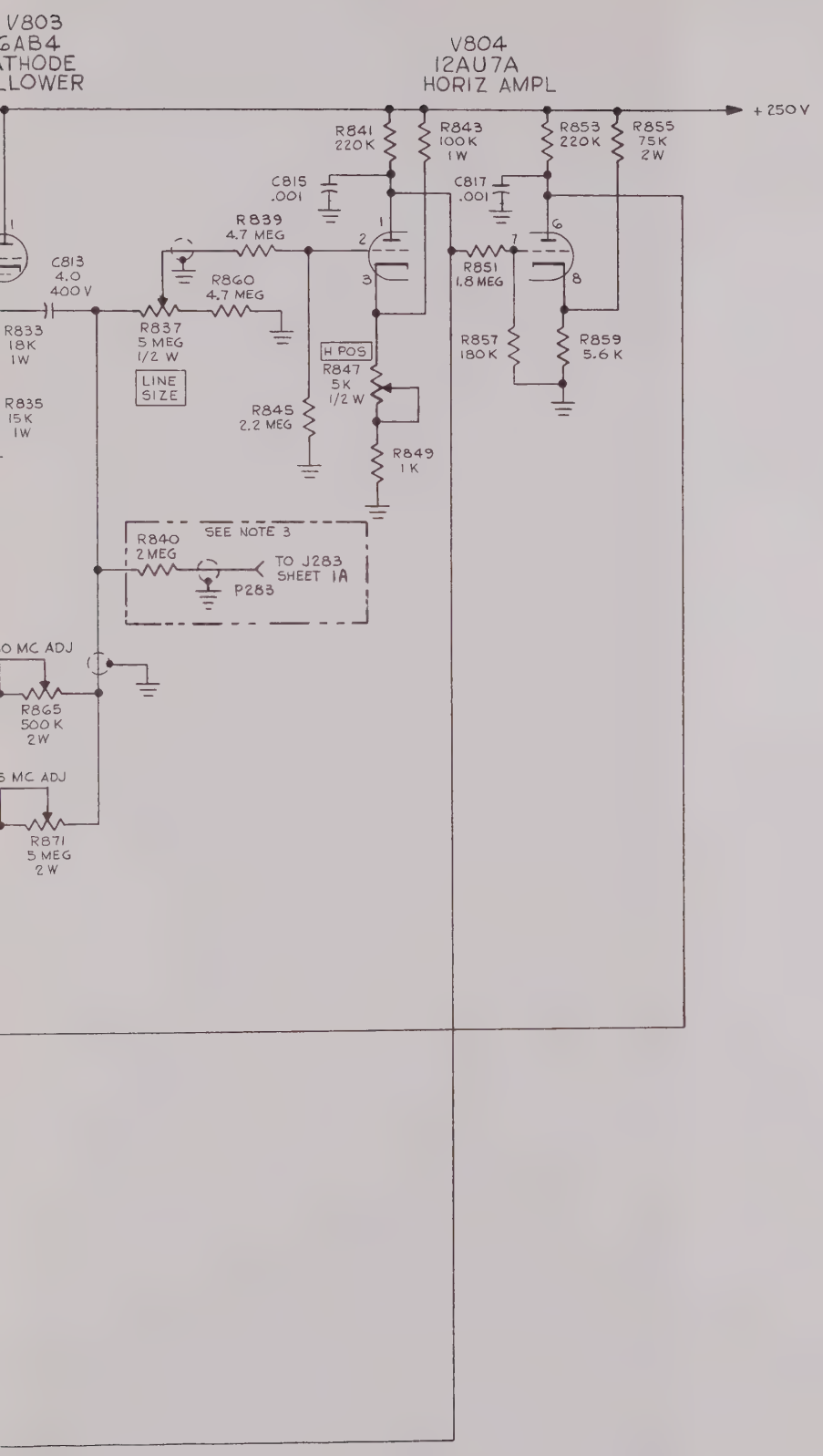
FACTORY ADJUST COMPONENTS		
SYMBOL	NOM VALUE	VALUE USED
R625	OPEN CKT	
R638	OPEN CKT	
R698	10K, 2W	
C644	20 PF	

4. C675, C677, J603, J605, R680, R684 USED ONLY WITH XYZ OPTION

556155-281 12 (Sheet 3)

Figure 7-4. Video I.F. Chassis, Schematic Diagram


V801
12AT7
SYNC AMPL
V802
6CB6A
SAWTOOTH
GENERATOR
R803
1MEGΩ
C803
.01
C805
.0047
400V
R805
220K
C807
.01
R807
100K
C801
.01
CAL SYNC
SEL
R813
100
R809
39K
R810
1K
R811
1MEGΩ
R814
3K
R815
50K
2W
SYNC
AMPL
C809
.022
150V
E801
NE-16
R817
10K
R819
100K
1W
R821
470K
R823
820K
C811
91 PF
R825A
5 MEG
2W
P261
S801A
C
PART OF
PG02
S801B
R801
470
CAL
EXT
LINE
DS801
V801
V802
V803
V804
R827
2.4K
R825B
50K
2W
R831
100K
SWEEP
RATE
-150V
TO J107
PINS 2,4 &
TO T102-15
TO T102-16
SWEEP WIDTH LIMITS
200 KC ADJ HIGH
K801
NC
NO
R861
10K
2W
R863A
2 MEG
2W
P307
SAWTOOTH OUTPUT
16
PART OF
P201
R862
1.2K
C820
5.0
50V
200 KC ADJ LOW
R867
10K
2W
R863B
2 MEG
2W
R873
200K
2W
SWEEP
WIDTH
TO
+2500 V
HV SUPPLY
PART OF
PG02
P105
J105
R701
5.1 MEG
2W
R703
5.1 MEG
2W
V701
5ADP1
VERT
HORIZ
R705
5 MEG
2W
FOCUS
C701
.005
3000 V
R707
3 MEG
1W
R709
1 MEG
2W
BRILLIANCE
C703
.005
3000V
C705
.05
500V
R711
1.5 MEG
R713
200K
TO T101-5
6.3V AC
TO T101-6
6.3V AC
TO P103
-2500 V

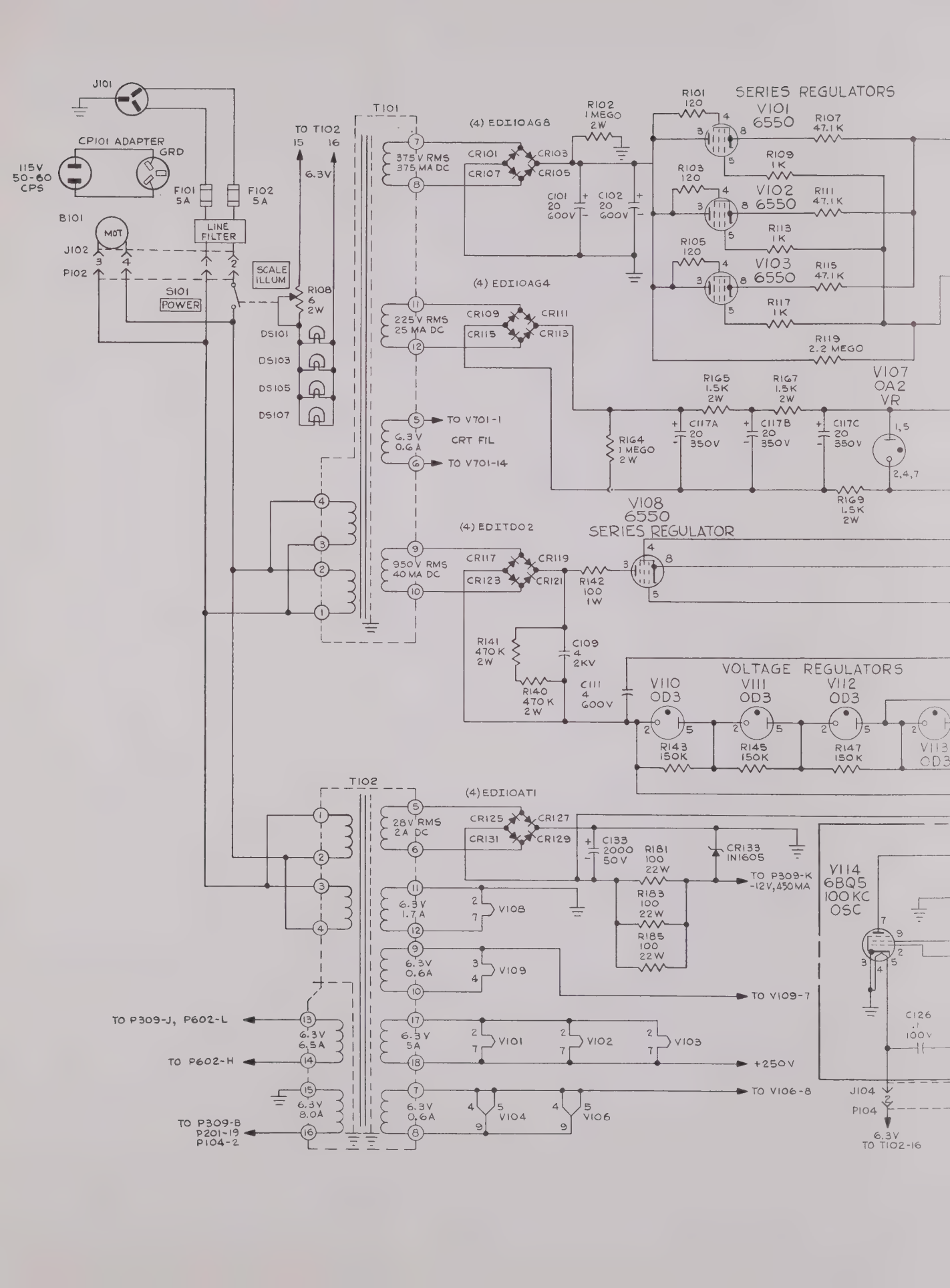


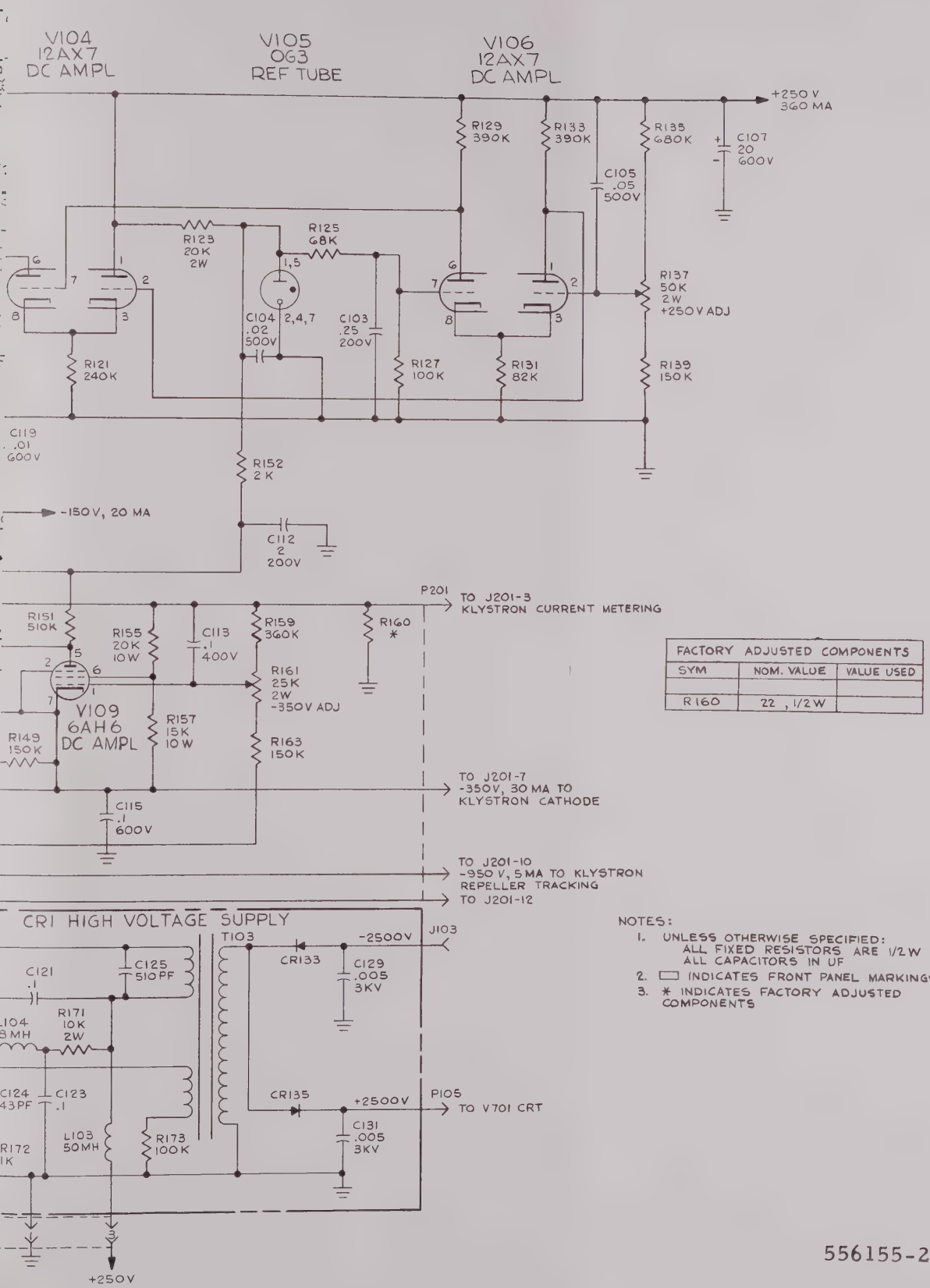
NOTES:

1. UNLESS OTHERWISE SPECIFIED:
   ALL FIXED RESISTORS ARE 1/2W
   ALL CAPACITORS ARE IN UF
2. ▭ INDICATES FRONT PANEL MARKINGS.
3. R840, P283 USED ONLY WITH XYZ OPTION.

556155-281 12 (Sheet 4)

Figure 7-5. Sweep Generator, Horizontal Amplifier and CRT, Schematic Diagram


J101
CP101 ADAPTER
GRD
115V 50-60 CPS
F101 5A
F102 5A
LINE FILTER
B101
MOT
J102
P102
S101 POWER
SCALE ILLUM
R108 6 2W
DS101
DS103
DS105
DS107
TO T102 15 16
6.3V
T101
(4) ED110AG8
375 V RMS 375 MA DC
CR101
CR103
CR107
CR105
C101 20 600V
C102 20 600V
R102 1 MEGO 2W
(4) ED110AG4
225 V RMS 25 MA DC
CR109
CR111
CR115
CR113
6.3 V 0.6 A
TO V701-1
CRT FIL
TO V701-14
(4) ED1TD02
950 V RMS 40 MA DC
CR117
CR119
CR123
CR121
R142 100 1W
R141 470 K 2W
R140 470 K 2W
C109 4 2KV
C111 4 600V
SERIES REGULATORS
R101 120
V101 6550
R107 47.1 K
R109 1 K
R103 120
V102 6550
R111 47.1 K
R113 1 K
R105 120
V103 6550
R115 47.1 K
R117 1 K
R119 2.2 MEGO
R165 1.5K 2W
R167 1.5K 2W
V107 0A2 VR
C117A 20 350V
C117B 20 350V
C117C 20 350V
R164 1 MEGO 2W
R169 1.5K 2W
V108 6550 SERIES REGULATOR
VOLTAGE REGULATORS
V110 0D3
V111 0D3
V112 0D3
V113 0D3
R143 150K
R145 150K
R147 150K
T102
(4) ED110AT1
28 V RMS 2A DC
CR125
CR127
CR131
CR129
C133 2000 50 V
R181 100 22W
CR133 IN1605
TO P309-K -12V, 450 MA
R183 100 22W
R185 100 22W
6.3 V 1.7 A
V108
6.3 V 0.6A
V109
TO V109-7
TO P309-J, P602-L
6.3 V 6.5A
TO P602-H
6.3 V 5A
V101
V102
V103
+250V
TO V106-8
TO P309-B P201-19 P104-2
6.3 V 8.0A
6.3 V 0.6A
V104
V106
V114 6BQ5 100 KC OSC
C126 .1 100 V
J104
P104
6.3V TO T102-16

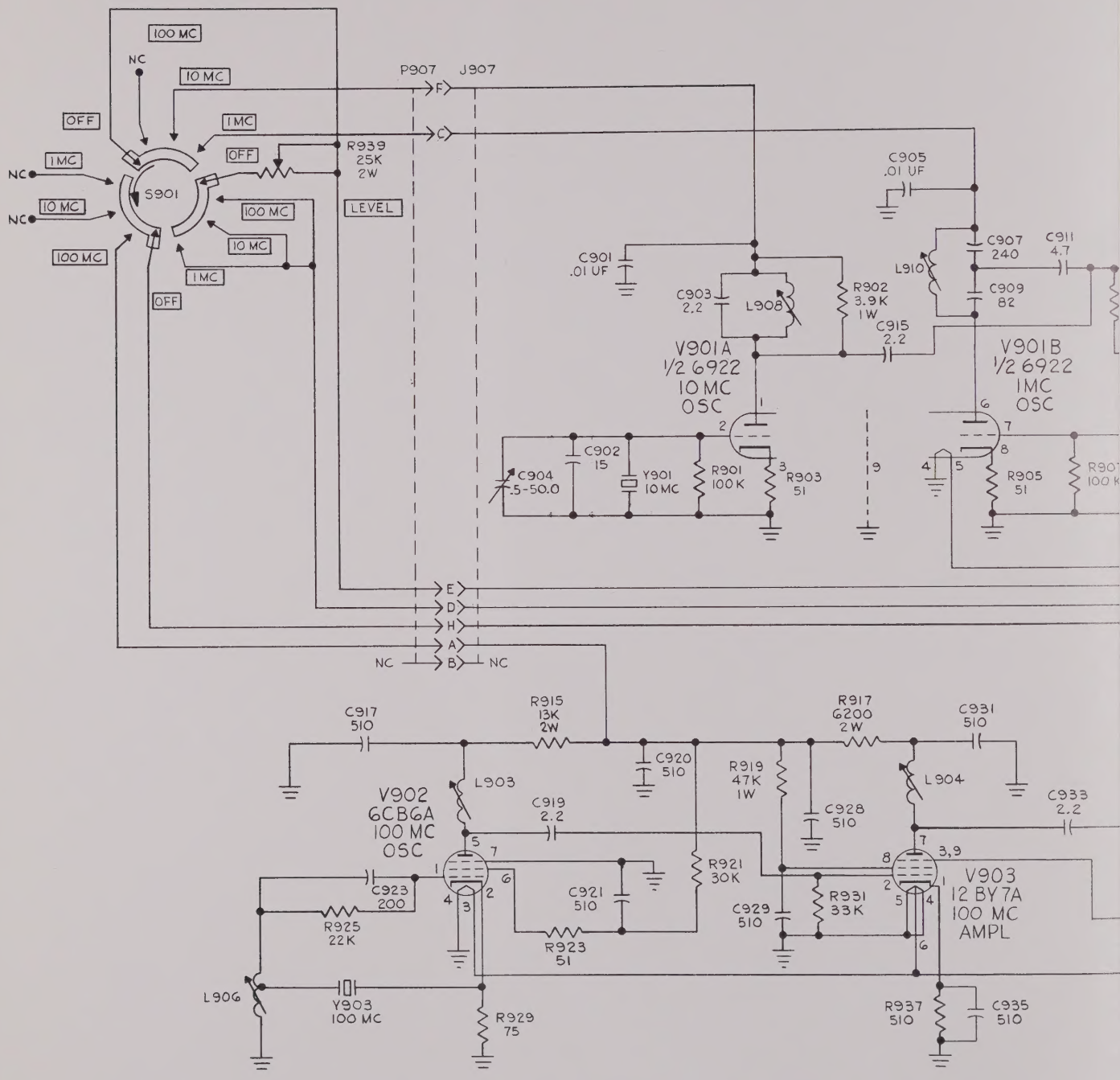


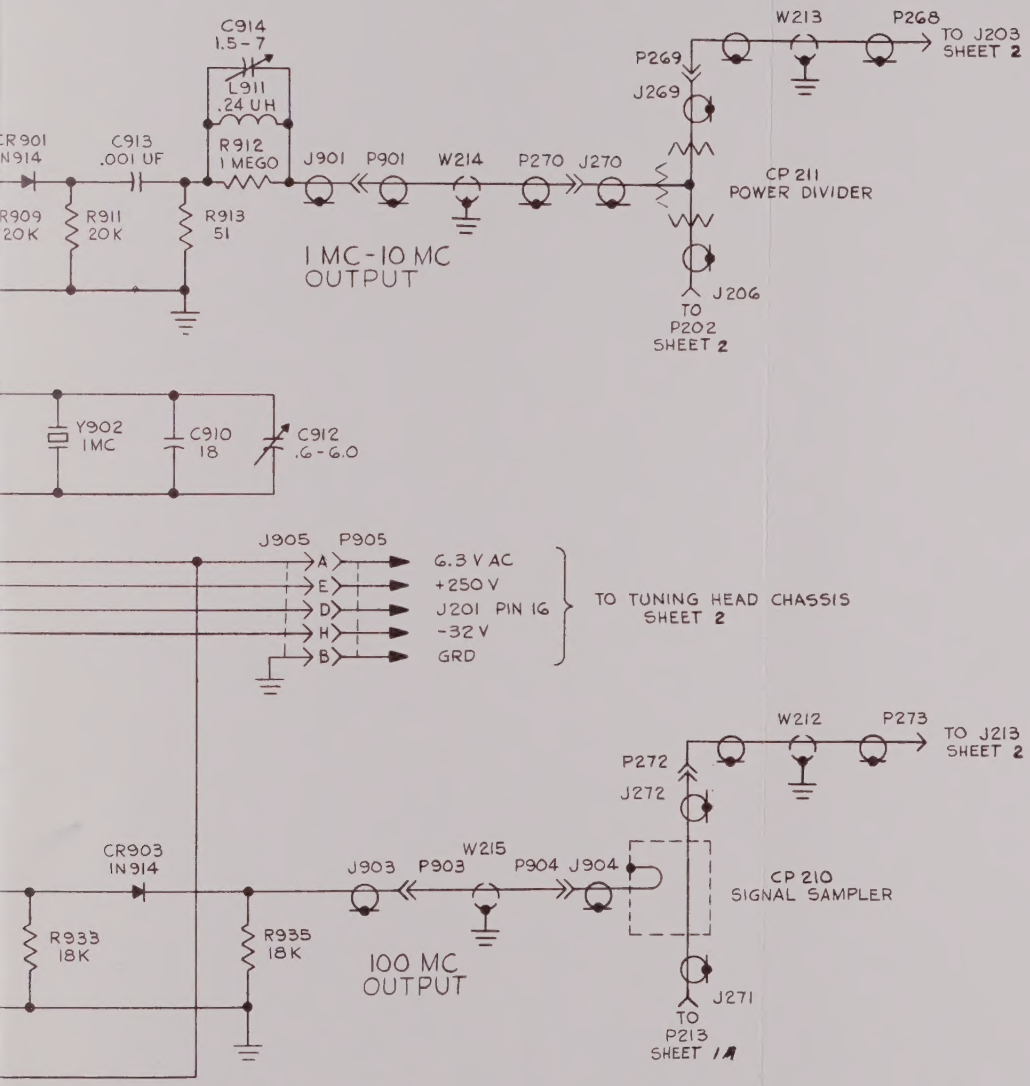
FACTORY ADJUSTED COMPONENTS		
SYM	NOM. VALUE	VALUE USED
R160	22 , 1/2W	

NOTES:
1. UNLESS OTHERWISE SPECIFIED:
   ALL FIXED RESISTORS ARE 1/2W
   ALL CAPACITORS IN UF
2. ▭ INDICATES FRONT PANEL MARKINGS.
3. * INDICATES FACTORY ADJUSTED COMPONENTS

556155-281 12 (Sheet 5)

Figure 7-6. Power Supply, Schematic Diagram


100 MC
NC
10 MC
1 MC
OFF
S901
LEVEL
R939
25K
2W
P907
J907
F
C
E
D
H
A
B
NC
C901
.01 UF
C903
2.2
L908
R902
3.9K
1W
C905
.01 UF
C907
240
C909
82
L910
C911
4.7
C915
2.2
V901A
1/2 6922
10 MC
OSC
V901B
1/2 6922
1MC
OSC
C902
15
C904
.5-50.0
Y901
10 MC
R901
100 K
R903
51
R905
51
C917
510
R915
13K
2W
C920
510
R917
6200
2W
C931
510
L903
L904
C933
2.2
V902
6CB6A
100 MC
OSC
C919
2.2
R919
47K
1W
C928
510
R921
30K
C923
200
R925
22K
C921
510
R923
51
C929
510
R931
33K
V903
12 BY 7A
100 MC
AMPL
L906
Y903
100 MC
R929
75
R937
510
C935
510



NOTES:

1. UNLESS OTHERWISE SPECIFIED, ALL FIXED RESISTORS ARE IN OHMS, 1/2 WATT.
   ALL CAPACITORS ARE IN PICOFARADS.
2. SWITCH VIEWED FROM OPPOSITE KNOB END; SWITCH IS IN EXTREME COUNTERCLOCKWISE POSITION.
3. CP210, CP211, W212 & W213 ARE ALSO SHOWN ON SHEET.
4. THIS IS AN OPTIONAL PART OF SPA-10.
5. ▭ BOXED IN CHARACTERS APPEAR AS FRONT PANEL MARKINGS.

556155-281 12 (Sheet 6)

Figure 7-7. Crystal Calibrator, Schematic Diagram